



# Research Digest

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## *Item 1*

### **Final Report on Monitoring and Evaluation of SH-130 Project Construction**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 4661-5 • 2007

This report provides an overview of the activities accomplished as a part of this study. Included in this overview are brief descriptions of each of the research products generated (as presented below in this chapter), and a description of three efforts that were ongoing at the time that this study was terminated by TxDOT:

- Procurement Change Implementation Framework (Chapter Two in this report)
- Project Performance Benchmarking (Chapter Three in this report)
- SH-130 Lessons Learned System (Chapter Four in this report).

Finally, this report presents some conclusions from the research.

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## *Item 2*

### **Planning for Container Growth along the Houston Ship Channel and Other Texas Seaports**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5068-2 • 2007

Study 0-5068 examined corridor improvement initiatives at all Texas seaports contemplating future container operations, with a primary focus on rail systems and current facilities under the Port of Houston Authority (POHA). This is the final study report and first estimates the volume of containers that could be handled by Port of Houston (POHA) terminals from 2004 to 2020. It then describes the Port Terminal Railroad Association (PTRA), which operates its own network and serves more than 173 major industrial sites and terminals along the Houston Ship channel. Next, it examines Houston issues related to highway movement of containers from the POHA terminals. The pattern of distribution centers in Houston serving as the most common first landside destinations for POHA containers is then described. A survey of the Houston dray industry and its driver workforce is then reported.

Since other deep-water Texas Gulf locations may have container terminals in future, consideration is given to the proposed terminals at Corpus Christi and Texas City. Finally, conclusions and recommendations from the two-year study are given, emphasizing issues most likely to impact transportation planning and programming in Texas.

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## *Item 3*

### **Before-After Comparison of Edgeline Effects on Rural Two- Lane Highways**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)

CTR 5090-2 • 2006

Pavement markings have definite functions in a proper traffic control system. They are applied for the purposes of regulating and guiding the movement of traffic, and promoting safety without diverting the driver's attention from the roadway. It was observed that pavement markings located to the right of the car are detected more easily and at distances farther away when compared with the corresponding markings placed to the left of the car.

However, compared to other types of longitudinal markings, the effect of edge lines on safety and driver behavior has been much less investigated. The conducted crash statistic analysis found that edge-line treatments on rural two-lane roadways may reduce accident frequency up to 26 percent and the highest safety impacts occur on curved segments of roadways with lane widths of 9 to 10 feet.

The next stage was focused on complex investigations of edge lines impacts on driver behavior and reactions, including vehicle navigational and positioning issues, speed selection, and effect on driver visual perception. Stationary traffic observation, test driving, and several laboratory experiments were conducted on the selected rural two-lane highways with different roadway width before and after edge lines placement.

Studies indicated that edge line treatments:

- increase speed on average by 5 mph or 9 percent on both straight and curved highway segments
- moves vehicles toward the pavement edge at both daylight and darkness in an average of 20 inches
- reduce vehicle fluctuation around trajectory center line by 20 percent
- reduce driver mental workload
- improve driver's estimation of roadway curvature
- increase driver's advance time of intersection identification.

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## *Item 4*

### **Recommendations for Reducing Superpave Compaction Effort to Improve Mixture Durability and Fatigue Performance**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5132-1 • 2007*

The Texas Department of Transportation (TxDOT) has recently established Hamburg Wheel Tracking Device (HWTD) specification criteria for Superpave mixtures (Item 344). This step has introduced a performance-related feature into an otherwise volumetric mix design approach structured to ensure asphalt mixtures with high shear resistance to rutting. The Superpave mixture design procedure is itself geared toward the production mixtures with high rutting resistance. This, together with the new HWTD criteria, tends to promote “dry” mixtures with lower binder contents than before. While this shift is advantageous for rutting resistance, some reports show that these mixtures are prone to cracking, which is becoming the single largest problem for hot-mix asphalt (HMA) pavements in Texas.

In an attempt to produce mixes with higher binder contents to alleviate cracking problems, this research study investigated the possibility of modifying the current design criteria established for Superpave mixtures. The initial findings of this study indicate that the current compaction effort expressed by the number of design gyrations ( $N_{design}$ ) could be lowered from 100 to 85 without significantly compromising the rutting resistance of the mixes, while improving cracking resistance and durability.

An extensive experimental program has been devised to investigate the performance characteristics of asphalt mixtures designed using the revised  $N_{design}$  levels and to account for the nominal maximum aggregate size and the concentration of coarse aggregate in the mix. The experimental matrix included two aggregate types (limestone and gravel), three binder grades (PG 64, 70, and 76), and three nominal maximum aggregate size (9.5, 12.5, and 19 mm). Although the testing was extensive, the recommendations in this report should be considered preliminary until more experimental evidence is gathered.

In addition, by reducing the compaction effort (for the same target density) the voids in the mineral aggregate (VMA) increase, thus making it easy to meet VMA specifications and ensuring a performing mixture.

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## **Item 5**

### **Preliminary Findings from Noise Testing on PFC Pavements in Texas**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)*

*CTR 5185-2 • 2007*

This report documents noise testing performed on Texas pavements in the summer and fall of 2006. Test methods include roadside noise measurement with SPL meters and on-vehicle sound intensity measurement of noise at the pavement tire interface. Comparisons are made between the levels of vehicular noise at the roadside and directly on the source vehicle. The FHWA Traffic Noise Model (TNM) computer program was then used to predict the noise levels at roadside based on the observed traffic and geometry of the roadway, and subsequently compared to the noise as actually measured with precision test equipment. The pavements tested were primarily of the New Generation Open Graded Friction Course type, a permeable asphalt design with air voids in the area of 17 percent, also known as Permeable Friction Course (PFC) in Texas. Preliminary findings indicate that roadside noise levels experienced along PFC pavements are significantly lower than predicted by TNM using either the "Average" or "Open Graded" pavement models included in the program. This suggests that further study is warranted to determine whether these pavements retain their acoustic properties over time and wear and, thus, can be reliably used for noise impact avoidance and abatement.

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## **Item 6**

### **Determination of Field Suction Values, Hydraulic Properties, and Shear Strength in High PI Clays**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)*

*CTR 5202-1 • 2007*

Moisture infiltration into highway embankments constructed by the Texas Department of Transportation (TxDOT) using high Plasticity Index (PI) clays results in changes in shear strength and in flow pattern that leads to recurrent slope failures. In addition, soil cracking over time increases the rate of moisture infiltration. The overall objective of this research is to determine the suction, hydraulic properties, and shear strength of high PI Texas clays. Specifically, two comprehensive experimental programs involving the characterization of unsaturated properties and the shear strength of a high PI clay (Eagle Ford clay) were conducted. These laboratory results allow characterization of the decrease in shear strength with time induced by successive cycles of wetting and drying. Also, the experimental hydraulic results allow quantification of the changes in unsaturated hydraulic properties due to cracking. Assessment of the influence of critical precipitation events is provided.

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## *Item 7*

### **Field Suction and Effect of Cracking in Highly Plastic Clay**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5202-2 • 2007*

A study was conducted to determine field suction values as well as the effect of cracking on the hydraulic properties of compacted highly plastic clays. This investigation consisted of an experimental program involving a series of instrumented soil column tests on highly plastic clay prepared under controlled compaction conditions and subjected to evaporation, infiltration, and a second evaporation stage. During both evaporation and infiltration stages, water content and suction profiles were measured. Analysis was conducted using the results of the experimental program to determine the effect of cracking on the hydraulic properties of the soil. This analysis indicates that cracking has a significant effect on the soil-water retention curve and the hydraulic conductivity of the compacted highly plastic clay under unsaturated conditions. The results of this analysis allow determination of field suction values and depth of moisture fluctuation. This study is complimented with slope stability analyses, evaluation of the recurrence rate of failures, and an overview of site visits conducted in this study.

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## *Item 8*

### **The Fully Softened Shear Strength of High Plasticity Clays**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5202-3 • 2007*

Previous research has shown that cyclic wetting and drying can reduce the shear strength of compacted highly plastic clays to the fully softened shear strength. Consolidated-undrained triaxial testing procedures were used to determine the fully softened shear strength of Eagle Ford Shale, which is a highly plastic clay found in central Texas. The measured secant friction angles of Eagle Ford Shale were also compared to a graphical relationship and an equation for computing the fully softened secant friction angle to verify the applicability of these correlations for the purpose of selecting strengths for design. Slope stability analyses were also performed to determine the pore water pressures and shear strength conditions that existed at the time of failure in the slope where the Eagle Ford Shale was obtained.

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## ***Item 9***

### **Identifying, Measuring, and Mitigating Environmental Justice Impacts of Toll Roads: Executive Summary Report**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5208-1 • 2007*

In 2004 the Texas Department of Transportation (TxDOT) funded the Center for Transportation Research at The University of Texas at Austin to develop a methodology to evaluate the environmental justice (EJ) impacts of toll roads given four scenarios: (a) the construction of new toll road(s), (b) converting existing non-toll roads to toll roads, (c) the tolling of capacity enhancements (e.g., additional main lanes or frontage roads to existing facilities), and (d) the conversion of planned non-toll roads to toll roads upon completion. This document presents an executive summary of the research performed in developing the EJ evaluation methodology to identify, measure, and mitigate disproportionately high or adverse impacts imposed on minority and low-income (EJ) communities by toll roads compared to non-toll roads.

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## ***Item 10***

### **Identifying, Measuring, and Mitigating Environmental Justice Impacts of Toll Roads**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5208-2 • 2007*

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## ***Item 11***

### **Guidebook for Identifying, Measuring and Mitigating Environmental Justice Impacts of Toll Roads**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)

CTR 5208-P2 • 2007

Highway funding constraints in recent years have resulted in the financing of new roads and the modernization of existing roads through investments that will be recovered by toll charges. In Texas, toll equity and Regional Mobility Authorities (RMAs) are voter-approved financial tools to leverage limited state transportation funds. Potential benefits for the Texas Department of Transportation (TxDOT) include savings as RMAs take responsibility for developing infrastructure projects, reduced maintenance expenditures associated with reduced traffic on department facilities, and additional revenue sources (TxDOT, Regional Mobility Authorities: Proposed Preamble). On December 16, 2003, the Texas Transportation Commission thus unanimously approved a policy that directed the TxDOT, RMAs, private developers, counties, and regional toll authorities to evaluate the feasibility of tolling all controlled-access mobility projects in any phase of development or construction (TxDOT, 2004). This directive applied to the following: new facilities, increased capacity (for example, adding frontage roads to existing main lanes), the conversion of existing non-toll roads to toll roads, and the conversion of planned non-toll roads to toll roads. This action fulfills the requirements of Texas House Bill 3588 passed during the 78th Legislature in May of 2003 (see text box) (Krusee, 2003), but it has also raised some questions about environmental justice (EJ) and how that relates to tolling.

Toll roads aiming at ensuring mobility, accessibility, and increased travel times may have unintended consequences. Inherently, transportation investments almost always create a disparate impact in that benefits are not equally distributed to all communities impacted by the investments. EJ becomes an issue when minority or low-income communities (referred to as EJ communities) receive fewer benefits and either are or may be disproportionately burdened by transportation investments. The burdens may be the result of negative social, economic, or environmental impacts imposed on those living in the impacted toll project area. But toll road projects could also have additional benefits for EJ communities compared to non-toll road projects. The objective of this guidebook is to present an approach for the identification, measurement, and mitigation of disproportionately high or adverse impacts imposed on minority and low-income (EJ) communities by toll roads relative to non-toll roads.

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## ***Item 12***

### **Toll Collection Technology and Best Practices**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)

CTR 5217-P1 • 2007

In this research product, tolling practices and technologies are presented. Likely developments and enhancements are reviewed, along with potential tie-ins to other Intelligent Transportation Systems (ITS) deployments. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to link the tolling function to other desirable transportation system management functions.

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## **Item 13**

### **Electronic Vehicle Identification - Industry Standards, Performance, and Privacy Issues**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)

CTR 5217-P2 • 2007

In this research product, industry standards for dedicated short range communications (DSRC) are reviewed, followed by an evaluation of costs and performance. Privacy concerns regarding collection and use of data on vehicle movements are examined in the context of existing and potential legislation, and issues in electronic vehicle registration are introduced. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to link the tolling function to other transportation system management functions.

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## **Item 14**

### **Developing Freight Highway Corridor Performance Measure Strategies in Texas**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)

CTR 5410-1 • 2006

This one-year scoping study examined the current status of highway Freight Performance Measure (FPM) implementation in the United States for possible implementation within the Texas Department of Transportation's (TxDOT) division of transportation, planning, and programming. A review of current FPM work revealed several state and federal initiatives and led the team to work closely with American Transportation Research Institute (ATRI) staff in determining Texas-based FPM data for the state. The study sponsored a FPM workshop, in which federal initiatives were presented together with study findings on current performance-based work. This report presents a review of current FPM work, details the ATRI-FHWA study currently underway, presents some early ATRI data on Texas highways, explores the potential interface between FPM corridor work and the Texas Transportation Institute (TTI) urban performance indices, and finally, makes recommendations for TxDOT on future FPM research and implementation in the state.

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## *Item 15*

### **Best Practices: Separation Devices between Toll Lanes and Free Lanes**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)*

*CTR 5426-1 • 2007*

Transportation agencies around the nation find themselves pushing the envelope of innovation to keep up with congestion caused by exploding demand for limited roadway space. Managed lanes provide a mechanism for harnessing the potential of the current infrastructure. Special-purpose lanes, including high-occupancy vehicle (HOV) and high-occupancy toll (HOT) lanes, allow engineers to manipulate roadway parameters to achieve varying levels of service.

Managed lanes are controlled access facilities, and must somehow be separated from general-purpose lanes. One principle question that must be asked is what type of delineation technique should be used? What are the properties of different delineators that make some more favorable than others? How do roadway characteristics, such as available width and traffic volume, factor into the choice of delineation? Much has been written on the safety and cost aspects of different delineation techniques used for HOV lanes; are these analyses applicable to other managed lanes as well? What about the other characteristics of the techniques: what are they, and how important are they to the choice of delineation? This report addresses some of these questions and sheds some light on their ultimate answers.

Three basic categories of delineation exist: concrete barriers, pylon posts, and painted buffers. This research project assembled an expert panel to gather a collective knowledge of factors involved in the choice of delineation most appropriate to given scenarios. The summary of this panel's discussions, included in this report, will serve as a useful guideline for engineers looking to choose the best type of delineation for future, successful managed lane projects.

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## **Item 16**

### **Mechanistic-Empirical Data Collection Approach for Rigid Pavements**

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 5445-1 • 2007

This report summarizes the tasks performed for TxDOT Research Project 0-5445 “Project Level Performance Database for Rigid Pavements in Texas.” Other pavement databases have been evaluated and their successes and failures have been considered for the preparation of this database. It is intended that the information obtained for this study is fully useful for the validation and calibration of a mechanistic-empirical (M-E) model. A database structure has been proposed and data collection efforts have followed a methodology that will ensure the quality of the data. To address the M-E component, researchers reviewed the continuously reinforced concrete pavement (CRCP) design logic adopted in the mechanistic empirical pavement design guide (MEPDG) and performed sensitivity analysis. In the MEPDG, two design criteria were selected for CRCP performance—IRI and punchouts. Because only punchouts were included in IRI prediction, punchouts represent the only structural distress analyzed in MEPDG. Top-down cracking was adopted as the only mechanism for punchouts. Experience in Texas and Illinois indicate that there might be punchouts mechanisms other than top-down cracking. Sensitivity analysis was performed for key input variables to evaluate the reasonableness of the outputs from MEPDG. The results indicated that zero-stress temperature, and the percent and depth of the longitudinal steel, have substantial effects on punchouts.

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## **Item 17**

### **Maintenance Solutions for Bleeding and Flushed Pavements Surfaced with a Seal Coat or Surface Treatment**

TEXAS TECH UNIVERSITY (TECHMRT)  
TechMRT 5230-1 • 2007

This report summarizes the findings of research directed at identifying maintenance solutions for bleeding and flushed asphalt pavements surfaced with seal coats or surface treatments. Although the basic mechanism associated with both bleeding and flushing has to do with excess asphalt binder filling the voids between aggregate particles, the terms are different - "flushed" is past tense; whereas, "bleeding" is an active verb.

Factors that contribute to bleeding and flushed pavements include aggregate issues, binder issues, traffic issues, environmental issues and construction issues. There is no better advice for dealing with bleeding and flushed pavements than to avoid the problem from the outset.

Bleeding is an immediate maintenance problem that must be addressed using corrective or in some cases, emergency, maintenance. The basic approaches used treat flushed pavements either (a) retexture the existing flushed pavement surface or (b) add a new textured surface over the flushed pavement.

Our research suggests that the use of polymer modified and other binders has improved seal coat and surface treatment performance such that bleeding and flushing problems are becoming less common. Three promising areas for further research and implementation relative to bleeding/flushing solutions include (a) use of lime water, (b) ultra high pressure water cutting, and (c) use of the racked-in seal at intersections.

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## **Item 18**

### **Maintenance Solutions for Bleeding and Flushed Pavements**

*TEXAS TECH UNIVERSITY (TECHMRT)*

*TechMRT 5230-P1 • 2007*

This report summarizes the findings of research sponsored by the Texas Department of Transportation (TxDOT) directed at identifying solutions to the problem of bleeding and flushed asphalt pavements with seal coats or surface treatments.

The research focused on documenting typical manifestations of bleeding and flushing, discovering the cause(s) and underlying factors that contribute to bleeding / flushing, and identifying cost-effective treatment approaches.

In addressing these challenges, the research synthesized literature and related information from sources outside TxDOT and also attempted to capture the wealth of institutional knowledge and expertise resident within the agency, both at the Division and District levels. The research challenge was to boil everything down to a manageable number of definable practices for treating (or preventing) the bleeding / flushing problem.

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## **Item 19**

### **Long-Term Research on Bituminous Coarse Aggregate: Use of Micro-Deval Test for Project Level Aggregate Quality Control**

*TEXAS A&M UNIVERSITY, TEXAS TRANSPORTATION INSTITUTE (TTI)*

*TTI 1707-9 • 2007*

This research evaluated the feasibility of implementing the Micro-Deval (MD) test in the Texas Department of Transportation's (TxDOT) Aggregate Quality Monitoring Program (AQMP) for bituminous coarse aggregate. In particular, the research investigated the possibility of using this test as a project level quality control tool. The study included review and analysis of TxDOT's Materials and test lab's AQMP data as well as independent laboratory testing. The findings showed that the Micro-Deval and magnesium sulfate soundness (MSS) tests are not adequately well correlated to allow the MD test to be used as a surrogate test for the MSS test. Alternative variations of the MD test did not yield significant improvement in the strength of the MD-MSS correlation. Based on these findings, it is recommended that an additional specification be introduced based on the MD test and this specification limit used for the purpose of project level quality control. The excellent repeatability of the MD test allows a smaller tolerance to be used in stockpile testing. Because of this the short testing time, the MD test will be an effective project level quality control test.

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## **Item 20**

### **Dynamic Message Sign Message Design and Display manual**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 4023-P3 • 2007

This Dynamic Message Sign Message Design and Display Manual was written for use by Texas Department of Transportation (TxDOT) personnel who have responsibility for the operation of and/or message design for large permanent dynamic message signs (DMSs) or portable DMSs. The Manual is designed to help both new and experienced users of DMSs at various levels of the agency including 1) entry-level personnel, 2) personnel very experienced with traffic operations, and 3) managers. It provides very specific information for entry-level personnel, reminders for experienced personnel, and higher-level information for managers regardless of whether they work in one of the Traffic Management Centers (TMCs) in the state.

The Dynamic Message Sign Message Design and Display Manual contains the following 22 modules: 1) Introduction, 2) Principles of DMS Operations, 3) DMS Operating Fundamentals, 4) Principles of DMS Message Design, 5) Designing the Base DMS Message for Incidents, 6) Designing the Base DMS Message for Roadwork, 7) Establishing the Maximum Message Length, 8) Dealing with Long Messages, 9) Designing DMS Messages for Incidents, 10) Designing DMS Messages for Roadwork, 11) Quick Reference Guide for Designing DMS Messages, 12) Modifying Messages to Improve Effectiveness, 13) Priorities When Competing Message Needs Arise, 14) Message Design Examples for Incidents: Large DMS, 15) AMBER Alert, 16) Catastrophic Event, 17) High Water and Flood, 18) Ozone, 19) Planned Special Events, 20) Hurricane Evacuation, 21) DMS Operations Policies, and 22) DMS Operations Procedures and Guidelines.

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## **Item 21**

### **Red-Light-Running Handbook Workshop Series: Year 2 Summary Report**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 4196-01-2 • 2006

A recent analysis of Texas crash data indicated that there are about 121 fatal crashes each year in Texas that are attributable to red-light violations. It was also found that about 37,702 red-light-running-related crashes occur each year in Texas. These crashes have a societal cost to Texans of about \$2.0 billion dollars each year. Engineering and enforcement countermeasures have been shown to reduce red-light violations, related crashes, or both by at least 10 to 30 percent. If even a 10 percent reduction in crashes were obtained by the use of one or more countermeasures, Texas motorists could save \$140 million annually.

This report describes the activities undertaken to conduct a series of intersection safety workshops. The focus of the workshop is on countermeasures intended to treat intersections with frequent red-light violations and related crashes. The activities undertaken include developing the workshop training materials, identifying the workshop venues, scheduling the workshops, encouraging attendance by city and county engineers, conducting workshops, and administering a course evaluation form.

A ten-workshop series was completed during the project. The course evaluations completed by the participants indicate a high degree of satisfaction with the course content and format. Recommendations are made regarding the need for additional research to quantify the effect of some engineering countermeasures.

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## *Item 22*

### **Pilot Implementation of a New System to Calculate IRI Used for Pavement Design Procedures - Technical Report**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)  
TTI 4518-01-1 • 2007

The pilot implementation of the new system to calibrate IRI used for pavement design purposes and applied to the design of pavements on expansive clays subgrades was conducted successfully. Six training sessions were conducted in three districts: three for design engineers and three for laboratory technicians. Three sets of testing equipment were received, set up, calibrated, and made operational in the three district labs. Two computer programs, one for design and the other for the analysis of a pavement cross-section, to determine the expected performance of expansive clay roughness countermeasures were delivered to the three districts. User guides for each of the programs were provided to each of those in attendance.

Full-text PDF of this report is available for free download from

<http://tti.tamu.edu/documents/5-4518-01-1.pdf>

## *Item 23*

### **Guidelines for the Evaluation of Dynamic Message Sign Performance**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)  
TTI 4772-1 • 2007

The objective of this research project was to determine appropriate guidelines and methodology for evaluating dynamic message sign (DMS) performance. National literature reviews and agency surveys were conducted and synthesized for a critical assessment of the state-of-the-practice in DMS performance evaluation. DMS performance metrics were established based upon data availability, time of evaluation (pre-post), and environment of evaluation (urban/rural). Both qualitative and quantitative DMS benefits were established with examples of associated analysis tools given and discussed. Case studies were conducted along freeway corridors where DMSs had been implemented in both urban (Houston, Texas) and rural (Amarillo, Texas) environments. The results of these case studies highlighted constraints in both data availability and appropriate analysis procedures. Final guidelines and methodology for DMS performance evaluation were produced emphasizing the limitation to assessment of both qualitative and quantitative benefits. A guidebook of DMS performance evaluation procedures was included as Appendix D in the research report.

Full-text PDF of this report is available for free download from

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# Research Digest

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## **Item 24**

### **Repair/Retrofit Anchorage Designs for Bridge Rails**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 4823-T1-1 • 2007

This project focused on developing alternative rail anchorage systems for the T501 and T203 bridge rail systems. The project considered only epoxy adhesive anchoring systems for each of these railings, for use in repair and retrofit situations. Strength data on the existing T501R “bolt-through” retrofit design is not well-defined. A tested retrofit design for the T203 did not exist at the time of starting this project. During this project, documented data on the strength characteristics of the conventionally anchored T501 and T203 bridge rail systems were obtained. These data were analyzed and used to develop alternate rail anchorage systems for both the T501 and T203 bridge rails. Long-term durability of epoxy anchoring systems was also considered based on information provided by the epoxy adhesive manufacturer.

The retrofit/repair strengths from the dynamic and static testing for both the T501 and the T203 compared very closely to the dynamic and static strengths of the conventionally anchored (As-Is) strengths capacities. In summary, the strengths of the retrofit designs were very close and in some tests exceeded the calculated capacities of the bridge rails. The static strengths were very close to the dynamic 50 millisecond average strengths recorded from the dynamic tests.

The new retrofit/repair designs developed and tested for this project are recommended for implementation for use on any new or existing bridge projects. The use of commercial adhesive anchor systems (Hilti RE 500 Adhesive Anchoring System) was very successful in achieving the strengths needed to adequately anchor the retrofit/repair reinforcement for both the T501 and the T203 bridge rails. The information learned from this project can be used to retrofit and repair other bridge rail designs in the future.

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## **Item 25**

### **A Unit Cost and Construction Specification Framework for Utility Installations**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 4998-1 • 2007

The Utility Accommodation Rules (UAR) prescribe minimums relative to the accommodation, location, installation, adjustment, and maintenance of utility facilities on the state right of way (ROW). The UAR only cover basic requirements, which makes it necessary to rely on additional guidelines, specifications, and special provisions to handle situations that are not covered by the rules. Because of the lack of standard utility installation construction specifications at TxDOT, many different versions of special specifications and special provisions exist around the state. Closely related to the need to standardize construction specifications for utility installations is the need to standardize methodologies and procedures for the determination of utility relocation costs. In practice, utility companies use a variety of ways to submit utility relocation costs for reimbursement. This lack of standardization translated into difficulties such as how to verify the validity of the cost data submitted for reimbursement and how to adequately prepare for audits and other internal and external inquiries.

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## **Item 26**

### **Construction Specification Requirements for Water and Sanitary Sewer Installations**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 4998-2 • 2007

Because of lack of standard utility installation construction specifications at the Texas Department of Transportation (TxDOT), many different versions of utility installation special specifications and special provisions exist around the state. Those specifications and provisions frequently contain very similar information. Closely related to the need to standardize construction specifications for utility installations is the need to standardize methodologies and procedures for the determination of utility relocation costs. In practice, there is a wide range of ways in which utility companies submit utility relocation costs for reimbursement. This lack of standardization translates into difficulties such as how to verify the validity of the data utility companies provide and how to adequately prepare for audits and other internal and external inquiries.

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## **Item 27**

### **Transportation Operations Data Needs and Recommendations for Implementation**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5257-1 • 2007

The operation and management of the transportation network generated enormous amounts of data. These data are a valuable asset to TxDOT users and, increasingly, external users as well. Frequently, data formats are incompatible and the data reside on incompatible storage media with different levels of accuracy and resolution. As a result, districts are finding that managing their operations data is an increasingly difficult task, which is only getting worse as the amount of data produced continues to grow. These inefficiencies result in unnecessary data redundancy, data integrity and quality control problems, underutilization of the data, and higher operating costs.

This report summarizes research conducted to assess transportation operations data characteristics, with a focus on data needs, data flows, and recommendations to help optimize the production, use, and archival of transportation operation data. The report describes the process to characterize current and potential data operations user needs, summarizes procedures and systems other state DOTs use for managing transportation operations data, describes a database model that represents information collected through surveys, summarizes relevant data management practices and implementation plans at TxDOT, outlines strategies for managing the data, and formulates implementation guidelines.

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## *Item 28*

### **Operations-Oriented Performance Measures for Freeway Management Systems : Year 1 Report**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5292-1 • 2007

This report describes the year 1 activities on the project titled "Operations-Oriented Performance Measures for Freeway Management Systems." Work activities included a comprehensive statewide survey on the use of performance measurement, as well as the initial recommendation on both operations and emissions-oriented performance measures to use in support of daily operations.

Full-text PDF of this report is available for free download from

<http://tti.tamu.edu/documents/0-5292-1.pdf>

## *Item 29*

### **Rail Relocation Projects in the U.S. : Case Studies and Lessons for Texas Rail Planning**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5322-1 • 2007

Freight transportation is a major component of the transportation activity in metropolitan areas of Texas where both highway and rail routes converge. Traffic conflicts in urban areas are especially acute in areas surrounding urban rail facilities. Rail operations are also greatly hindered in urban rail facilities, which are often surrounded by incompatible land-use activities. One approach to addressing urban vehicle-rail conflicts and urban rail operations issues is to consider the relocation of train operations to new rail corridors located outside urban boundaries.

This project examines rail relocation projects in the United States to determine best practices, document project costs and expected benefits, and develop recommended policies for TxDOT use in assessing potential urban rail relocation projects throughout the state. Case studies deliver information on a broad variety of issues to be considered in railroad relocation projects including example project costs, impacts upon urban and outlying communities, potential funding mechanisms, and how potential rail relocation projects may be integrated with planning for other transportation improvements.

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## **Item 30**

### **Design Considerations for Flexible Pavement Widening**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5429-1 • 2007

The Texas Department of Transportation, TxDOT, prepared Safety Bond Projects that were to undertake the letting of construction projects for flexible pavement widening on current pavement widths less than 24'. Typically, these projects were approximately 20 foot widths, where widening will extend the pavement width to approximately 27 to 28 feet.

Few guidelines exist statewide for assisting designers in selecting the appropriate widening technique. Current specifications provide a basic framework for construction performance and compaction; however, there are major pavement related issues that are not addressed. Some of these issues include: meeting density requirements on narrow sections, placing the joint in the wheel path, and not matching pavement sections, which can cause moisture to be trapped in the original structure.

To address these considerations and others, this project focused on an extensive literature review and a survey of various district personnel regarding project selection and issues faced during construction of widening projects. This study concluded with a site-specific approach to selection of proper material use and/or re-use, construction technique and traffic control to warrant rapid construction and long-term stability of the widened pavement, which is summarized into a flexible pavement widening guideline.

Full-text PDF of this report is available for free download from

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## **Item 31**

### **Preliminary Guidelines for Signing on Toll Facilities**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5446-1 • 2007

A review of current practice for signing on toll facilities is presented. A new chapter for the Texas Manual of Uniform Traffic Control Devices includes route markers, advisory plaques, guide signs, and independent route assemblies. Typical layout drawings for a variety of toll facilities are also included. Research activities regarding the comprehension of the signs in the new chapter included eight focus groups in three Texas cities which explored driver understanding of toll road traffic operations and payment options.

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# Research Digest

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## **Item 32**

### **Criteria for High Design Speed Facilities**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5544-1 • 2007

The TxDOT is embarking on a multi-decade effort to expand the state's transportation system. To accomplish this expansion, TxDOT has expressed an interest in using higher design speeds (above 80 mph [130 km/h]) to promote faster and more efficient travel within the state. Current state and national roadway design guidance does not provide criteria for design speeds above 80 mph [130 km/h], so design values are not available. The purpose of TxDOT Project 0-5544, Development of High Speed Roadway Design Criteria and Evaluation of Roadside Safety Features, was to expand upon existing design guidance and identify new criteria for design speeds up to 100 mph [160 km/h].

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## **Item 33**

### **Intermediate Access to Buffer-Separated Managed Lanes**

TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)

TTI 5547-1 • 2007

The objective of this Texas Department of Transportation (TxDOT) research project was to develop guidance materials on intermediate access to a buffer-separated toll lane. To develop the material, researchers gathered other state guidelines, reviewed the literature, and recorded operations at five intermediate access sites. From videotapes of the sites, characteristics of approximately 8400 vehicles that moved into or out of the managed lane were recorded. Examples of the characteristics measured included where the vehicle entered or left the lane (early, within the opening, or late) and the lane of origin for the vehicle. Volume counts for 5-minute periods were associated with each maneuver. Approximately 9 percent of the vehicles crossed the solid white markings (i.e., were not in compliance with the pavement markings). Compliance was better for the longer access opening length (1500 ft) as compared to the 1160-ft access opening length. A surprisingly large number of maneuvers at the intermediate access openings (over 7 percent) involve vehicles passing slower-moving vehicles. At the two sites with the larger quantity of data between 40 and 80 percent of the passing vehicles involved a vehicle leaving the managed lane to pass a slower-moving managed-lane vehicle. Findings from one field site demonstrated that when presented with the opportunity to enter a managed lane that is located very close to an entrance ramp, drivers will attempt to cross multiple lanes to do so.

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## **Item 34**

### **Nanotechnology Synthesis Study: Research Report**

*UNIVERSITY OF HOUSTON. DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING (UH)  
UH 5239-1 • 2007*

In this project, we investigated the potential nanotechnology applications in highway pavements mainly in two different categories: smart materials for pavement construction and sensors for transportation and pavement infrastructure condition monitoring. The smart materials are applicable to pavement construction, including concrete, asphalt, aggregates, and pavement marking materials; and the sensors, including temperature sensor, strain sensor, pressure sensor, accelerometer, and moisture sensor, now form a reliable, accurate, low-cost network and are suitable for transportation and pavement infrastructure condition monitoring. Radio frequency (RF) microelectronic monitoring systems (MEMS) technology is an advanced and innovative MEMS sensor technology which transmits MEMS sensor data wirelessly at a high speed securely. Ultra-low-cost RF MEMS sensors can be placed in pavements, bridges, and even inside concrete and asphalt in large quantities to form a local RF MEMS sensor network for different pavement infrastructure monitoring purposes. Nanomaterials are very attractive to the Texas Department of Transportation (TxDOT). Though nanomaterials are still in the research and development states and are not cost effective for implementation at this time, nano-based sensors are getting mature and can be used in TxDOT for monitoring and other applications. IN order to demonstrate the applications of nanotechnology in transportation systems, a fully functional smart stop sign is developed and tested. This smart stop sign is able to detect any malfunction including direction change, fall down, or tilt and report wirelessly to the TxDOT office using nanosensors and MEMS radio technology.

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## **Item 35**

### **Evaluation of Binder Tests for Identifying Rutting and Cracking Potential of Modified Asphalt Binders**

*UNIVERSITY OF TEXAS AT EL PASO (UTEP)  
UTEP 4824-1 • 2007*

To minimize premature failures, the Strategic Highway Research Program (SHRP) proposed binder tests that can identify poorly performing binders. To meet new performance grade specifications, a modifier is typically added to the binder. Occasionally, state highway agencies specify a particular modifier type and modifier content to be included in the binder.

However, the specified asphalt binder or tests do not necessarily identify the presence of modifiers. Therefore, the focus of the research was to identify a suitable binder test that can detect the presence of modifier and rutting and cracking potential of hot mix asphalt concrete. In addition, the purpose of the study was to identify whether a particular modifier is better in comparison to the other available modifiers or they provide the similar performances.

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## **Item 36**

### **Performance Evaluation of HMA Consisting of Modified Asphalt Binder**

UNIVERSITY OF TEXAS AT EL PASO (UTEP)

UTEP 4824-2 • 2007

To achieve Strategic Highway Research Program (SHRP) specified PG grades, refineries make use of modifiers to enhance the properties of base asphalt. Even though modified binders may meet PG specifications, some perform better than others. This can be attributed to binder/hot mix asphalt (HMA) tests inability in consistently identifying the problems with the binders especially if the modifier is added to the binder. Therefore, it is necessary to identify a binder/HMA test that can consistently predict performance.

The research performed for SHRP has significantly increased the understanding of HMA mix behavior among national and international highway-related agencies, which has resulted in an increase in the number of mixes available for placement. The increase in mix types makes it difficult for designers to select the appropriate mix for a given application. Therefore, it is necessary to have a HMA selection guideline.

To achieve the objectives of this study, a survey was conducted to identify commonly placed mix and modifier types and logic followed in selection of mixes. Based on survey results, three mixes (Type D, CMHB-C, and PFC) were selected. In addition, the four modifier types: SBS, SBR, TR, and Elvaloy were selected and evaluated. The evaluation results and recommendations are included in this report.

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## **Item 37**

### **Effects of Pulverization on Properties of Stabilized Bases**

UNIVERSITY OF TEXAS AT EL PASO (UTEP)

UTEP 5223-1 • 2007

Pulverization of pavement base materials is routinely carried out for rehabilitation of roads through full-depth reclamation (FDR). The primary stabilizers currently used in TxDOT districts for FDR are cement, lime, and fly ash. The optimum stabilizer content is currently determined either based on experience or through a series of laboratory tests that evaluates the strength, stiffness and durability of the base-stabilizer mix. For lab testing, base materials are retrieved from the site way before pulverization. The change in gradation due to pulverization can significantly impact the base strength and stiffness.

Phase I of this study consisted of an extensive laboratory study to determine the impact of changes in gradation on the desired stabilizer content of a base material. The impact of pulverization was also studied on an ongoing project. The results are provided in this report. It was found that the change in gradation indeed impacts the properties of the mix and should be considered in the design stages of FDR. In Phase II, the ways to address this matter will be investigated and reported.

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*Item 38*

**Feasibility of Quantifying the Role of Coarse Aggregate Strength on Resistance to Load in HMA**

UNIVERSITY OF TEXAS AT EL PASO (UTEP)

UTEP 5268-1 • 2007

The performance of the new generation of HMA mixtures relying more on a stone-on-stone contact is greatly influenced by the properties of the aggregate blends such as gradation and strength. As a result, aggregates have a significant and direct effect on the performance of asphalt pavements and it is important to maximize the quality of aggregates to ensure a proper performance of roadways. Several methods are available to determine the aggregate characteristics but their relationship to field performance, aggregate structure in HMA and traffic loading needs to be further investigated and defined.

The objective of this research is to evaluate the effect of stress concentrations at contact points on coarse aggregates that could cause aggregate fracture. The validation effort involved subjecting individual aggregates as well as HMA mixtures prepared with different aggregates to full-scale the performance of particles and blends to their respective characterization test methods.

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