Table of Contents

Fiscal Year 2006 Research Program  pg. 3
RMC 1 – Overview  pg. 5
RMC 1 – New Starts  pg. 9
RMC 1 – Continuing Projects  pg. 25
RMC 2 – Overview  pg. 53
RMC 2 – New Starts  pg. 57
RMC 2 – Continuing Projects  pg. 71
RMC 3 – Overview  pg. 81
RMC 3 – New Starts  pg. 85
RMC 3 – Continuing Projects  pg. 99
RMC 4 – Overview  pg. 117
RMC 4 – New Starts  pg. 121
RMC 4 – Continuing Projects  pg. 139
RMC 5 – Overview  pg. 161
RMC 5 – New Starts  pg. 165
RMC 5 – Continuing Projects  pg. 173
FISCAL YEAR 2006 RESEARCH PROGRAM

University Participation

TxDOT’s fiscal year 2006 research program consists of 160 projects, with budgets totaling $19.5 million. Almost all of this work is contracted to fourteen Texas state-supported universities. In addition, TxDOT has research project agreements in place with the United States Geological Survey (USGS), and conducts a small amount of research in-house. The figure below shows project agreement totals by university / research institution.
Research Management Committee (RMC) Funding

The table below shows a summary by RMC of the number of continuing and new projects, and total funding, for fiscal year 2006.

<table>
<thead>
<tr>
<th>RMC</th>
<th>Focus Area of RMC</th>
<th>Number of Continuing Projects</th>
<th>Number of New Projects</th>
<th>Total Project Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction, Pavements, &amp; Maintenance</td>
<td>27</td>
<td>16</td>
<td>$5,129,738</td>
</tr>
<tr>
<td>2</td>
<td>Transportation Planning</td>
<td>8</td>
<td>12</td>
<td>$2,566,811</td>
</tr>
<tr>
<td>3</td>
<td>Geometric Design, Right of Way, Environmental, &amp; Hydraulics</td>
<td>17</td>
<td>12</td>
<td>$3,505,956</td>
</tr>
<tr>
<td>4</td>
<td>Traffic Operations</td>
<td>22</td>
<td>17</td>
<td>$4,256,308</td>
</tr>
<tr>
<td>5</td>
<td>Structures</td>
<td>23</td>
<td>6</td>
<td>$4,017,600</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>97</strong></td>
<td><strong>63</strong></td>
<td><strong>$19,476,413</strong></td>
</tr>
</tbody>
</table>

The figure below shows the percentage breakdown of the total FY 06 program amount by RMC.

**Fiscal Year 2006 Program by RMC**

*Total = $19,476,413*
RMC 1 - Overview
### RMC 1 – New Starts

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5223</td>
<td>The Effects of Pulverization on Design Procedures</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5230</td>
<td>Short Term Solutions to &quot;Bleeding&quot; Asphalt Pavements</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5239</td>
<td>Nanotechnology Synthesis Study</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5261</td>
<td>Using Imaging Technology to Improve the Laboratory and Field Compaction of HMA</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5262</td>
<td>Optimizing the Design of Permeable Friction Courses (PFC)</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5268</td>
<td>Role of Coarse Aggregate Point and Mass Strength on Resistance to Load in HMA</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5310</td>
<td>The Evaluation of a System for Measuring Seal Coat Quality</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5444</td>
<td>Rehabilitation Procedures for Longitudinal Cracks and Joints Separation in Concrete Pavement</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5445</td>
<td>Project Level Performance Database for Rigid Pavements in Texas</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5472</td>
<td>A Data Base for Successful Pavement Sections in Texas - Including Both Experimental and Non-Experimental Pavements</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5482</td>
<td>Concrete Pavement Overlays over Existing Asphalt Pavement Structures</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5496</td>
<td>Tracking the Performance of HMA Mixtures in Texas</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5513</td>
<td>Development of a Flexible Pavements Database</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>Project Number</td>
<td>Title</td>
<td>End Date</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>0-1777</td>
<td>Field Synthesis of Geotextiles in Flexible and Rigid Pavement Overlay Strategies Including Cost Considerations</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4463</td>
<td>Using Profile Measurements to Locate and Measure Grind and Fill Areas to Improve Pavement Ride</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4505</td>
<td>Develop a Knowledge Management System for TxDOT Pavement-Related Corporate Knowledge</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4524</td>
<td>Application of Surface Energy Measurements to Evaluate Moisture Susceptibility of Asphalt and Aggregates</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4661</td>
<td>Monitoring and Evaluation of SH 130 Project Construction</td>
<td>3/31/2008</td>
</tr>
<tr>
<td>0-4687</td>
<td>Rubblization and Crack &amp; Seat as Major Rehabilitation for Concrete Pavements</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4760</td>
<td>Evaluation of Methods to Measure Ride (Profile) and Cross Slope on New Base Course and Pavements</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4822</td>
<td>Monitor Field Performance of Full-Depth Asphalt Pavements to Validate Design Procedures</td>
<td>8/31/2009</td>
</tr>
<tr>
<td>0-4826</td>
<td>Use of Crushed Gravel in Concrete Paving</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4829</td>
<td>Quantify the Benefits of Using Geosynthetics for Unbound Base Courses</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4863</td>
<td>Characterizing the Effects of Surface Roughness on Vehicle Dynamic Loads and Pavement Life</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>
### RMC 1 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4893</td>
<td>Performance of Old Concrete Under Thin Overlays</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5091</td>
<td>Analyze Existing Fog Seal Asphalts and Additives</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5106</td>
<td>Evaluation of Curing Membranes Effectiveness to Reduce Evaporation</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5123</td>
<td>Development of An Advanced Overlay Design System Incorporating Both Rutting and Reflection Cracking Requirements</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5132</td>
<td>Analysis of Laboratory Compactive Effort to Optimize the Durability of Superpave Mixture Design</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5135</td>
<td>Improving Correlation Between Field Construction of Soils and Bases and Laboratory Sample Construction Techniques</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5169</td>
<td>Constructability Review of Surface Treatments Constructed on Base Courses</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5179</td>
<td>Deep Mixing Technology for Mitigation of Pavement Roughness</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5185</td>
<td>Noise Level Adjustments for Highway Pavements in TxDOT</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5429</td>
<td>Considerations for Flexible Pavement Widening Projects</td>
<td>4/30/2006</td>
</tr>
<tr>
<td>9-1502-01</td>
<td>Model Calibrations with Local APT Data and Implementation for Focused Solutions to NAFTA Problems</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>
RMC 1 - New Starts
Abstract
Stabilization of some base materials with cement, fly ash and other additives are quite appealing as a means of rehabilitation of deteriorating roads. In this process, the materials are pulverized, mixed with additives and water, and compacted to produce a potentially strong and durable base. One of the concerns with this method is inadequate or excessive pulverization of granular bases during stabilization. The goal of this project is to study the impact of the pulverization on the quality of the final product in terms of strength, performance, and durability. To achieve this goal, at a minimum, the following important concerns have to be addressed:
• How does the pulverization process change the aggregate properties?
• Are the changes in properties significant enough to affect the original stabilization design?
• Do these changes contribute to an inferior product and to what extent?
• What activities are necessary to mitigate these problems? To address these questions, several steps will be taken. The extent of change to existing aggregate gradation during the fly ash/cement stabilization process will be studied at a number of sites constructed with different coarse aggregate types to understand the extent of the problem. Through lab and field study, the impact of the fineness of the aggregates on the final product will be studied. A guideline in terms of when and for which types of materials the stabilized base is no longer a viable option will be developed. These findings will then be synthesized and incorporated in a step-by-step procedure, from the initiation of the design to the completion of construction, using established technologies or strategies used for this purpose throughout the world. The final product will also contain recommendations to modify the TxDOT specifications and test methods that would be necessary to construct durable and well constructed pavements.

Research Products
• A tool for gradation adjustments and pavement structural adjustments for degraded stabilized bases
• Guidelines for stabilization of existing bases when excessive pulverization is observed
• Recommendation for any revisions to the standard specification Items 265 and 275
Abstract

The Texas Department of Transportation (TxDOT) is seeking cost-effective, short-term solutions to address the problem of "bleeding" or "flushing" asphalt for their pavements with seal coats and surface treatments. To address these challenges, the proposed research will identify and articulate best practices for the diagnosis, prevention and treatment of flushing/bleeding pavement surfaces.

The research challenge associated with establishing best practices for treating bleeding asphalt pavements is one of (a) gathering a wealth of information from many different sources, (b) sorting, evaluating and organizing this information, and (c) boiling everything down to a manageable number of definable practices for treating (or preventing) the problem. Meeting this challenge requires two things; first, initial insight and understanding about the problem, and second, a context and systematic method for data gathering and analysis.

The proposed research would be conducted in five tasks. We propose to begin with a literature review, international in scope (Task 1). Here the focus is on gaining breadth of information. Task 2 will consist of conducting structured interviews with various non-TxDOT knowledge sources, nationwide, in order to further develop and refine our understanding of the bleeding asphalt problem. In Task 3, we shift our data-gathering focus from breadth to depth and propose to conduct face-to-face interviews with knowledgeable persons within TxDOT at both the Division and District levels in order to capture the wealth of institutional knowledge and expertise resident within the agency. In particular, we propose to request construction data on selected recent projects where bleeding/flushing has been identified as a problem. With this information, we will investigate possible links between the bleeding/flushing performance issues and TxDOT Binder Quality Assurance data. Analysis of the data (Task 4) - consisting of practical, hands-on, performance-focused, expertise gained from international, national, and statewide sources - will be articulated as best practices for addressing the problem of bleeding asphalt pavements. Reporting (Task 5) will document our findings.
Abstract
After more than a decade of progress, the nanotechnology has just begun to impact highway materials and construction. The nanotechnology in transportation can be grouped into three categories: the kinetics of the chemical reactivity, the improvement of the performance of construction materials, and the transportation condition monitoring. The nano products in these three categories are applicable to the pavement materials including concrete, asphalt, aggregates, and even pavement marking materials, which are very important to Texas highways. In this project, we will study the recent development on these three categories.

Advanced sensor technology using nano chips are also available for transportation applications. Sensor data transmission has been switching from traditional wired system to wireless systems. Due to the lower cost and easy installation, sensors have been placed in the pavements, bridges, and even inside concrete and asphalt in large quantities for different purposes. In this project, we will not only study the nano sensors, but also sensor systems.

To verify the functionality of the nano technologies and their possible applications to highway research and applications, we will conduct practical measurements to the nano products to better understand their advantages and limitations including functionality, cost, characteristics, and methods of field installation.

Research Products
- Demo hardware and software to show functions of nano sensors and materials
- Demo wireless communications systems for nano device data transmission and data collection.

Research Universities and FY 2006 Budget
University Of Houston - $111,000

Total Project Budget
$111,000
**Project - 0-5261**
Using Imaging Technology to Improve the Laboratory and Field Compaction of HMA

**Start Date** - 09/01/2005
**End Date** - 08/31/2007

**Program Coordinator**
Ed Oshinski, AVN

**Project Director**
German Claros, RTI

**Project Advisors**
**Research Supervisor**
Eyad Masad, TTI

---

**Abstract**
This project will utilize imaging techniques to capture air void distribution in asphalt pavements and understand the influence of mix design and compaction on air void distribution. Consequently, this study will develop guidelines to improve the simulation of laboratory compaction to field compaction, and compact asphalt pavements with optimum air void structure.

Specific objectives of this project are to:

- Examine and document the details of air void distribution in laboratory compacted specimens and in field compacted specimens for different types of aggregate gradation and aggregate characteristics in representative mixtures used by TxDOT.
- Evaluate the possible changes to the laboratory compaction procedures to better resemble field compacted asphalt pavements.
- Determine the influence of compaction method, aggregate gradation, aggregate shape, and design volumetric properties on air void distribution.
- Identify air void distributions that are detrimental to asphalt pavement performance.
- Develop guidelines that include different types of compaction equipment and procedures to eliminate the detrimental air void distributions. The developed guidelines will lead to asphalt pavements with better performance.

---

**Research Products**
- Recommendations for Changes of Laboratory Compaction
- Guidelines for Field Compaction
- Test Protocol for analyzing air void Structure
- Guidelines describing desirable and undesirable air voids

---

**Research Universities and FY 2006 Budget**
Texas A&M University At Kingsville - $10,783
Texas Transportation Institute - $135,601

**Total Project Budget**
$296,701
Abstract
Porous friction course (PFC) mixtures are being utilized by TxDOT at an increasing frequency to address safety issues and possibly reduce noise. The current PFC mix design method is not well defined, and the construction and maintenance practices may not be consistent. The two goals of this project are to develop and recommend an improved PFC mix design method and to produce corresponding guidelines for construction and maintenance of these mixtures to ensure adequate performance. Researchers will first conduct a worldwide literature search and survey on PFC mix design, performance, construction, and maintenance that will utilize results from ongoing NCHRP and TxDOT projects. Laboratory characterization and field evaluation experiments will then be designed and completed to assess current TxDOT practices and determine if recent advances in mixture characterization can be utilized. Based on analysis and evaluation of the test results and field evaluations, this project will produce a summary report and three research reports that document the information search, recommended construction and maintenance guidelines, and provide an improved PFC mix design method that addresses functionality in terms of permeability and noise reduction and durability in terms of moisture damage and aging potential.

Research Products
- Draft PFC Mix Design Method
- Draft Test Procedures for Characterizing PFC
- Construction & Maintenance Guidelines for PFC

Research Universities and FY 2006 Budget
Texas Transportation Institute - $139,300

Total Project Budget
$277,900
Abstract

Increased loads on hot mix asphalt (HMA) pavements have necessitated mix design that rely more on stone-on-stone contact of the coarse aggregates. The strength properties of coarse aggregates are more significant in these new-generation asphalt mixtures in comparison to conventional mixtures.

Construction operations and traffic loadings can contribute to crushing and grinding of coarse aggregates at the contact points which can significantly alter the design gradation and expose uncoated aggregate faces. It is imperative that the contribution of the aggregate strength to the behavior of these new mixes under loading is understood and that methods are developed to measure this contribution during mix design. Several methods are available to determine aggregate characteristics, but their relationship to field performance, aggregate structure in HMA, and traffic loading needs to be further investigated and defined. Current laboratory protocols do not correlate well with aggregate abrasion, toughness, and strength requirements during handling, construction, and service. Specifications should ensure that aggregate particles possess the necessary strengths to avoid degradation during handling, construction, and trafficking. To address these questions, the characteristics of the aggregates have to be considered in a multifaceted way, which require close collaboration between geologists, geotechnical engineers and those specialized in hot mix asphalt pavement design and construction. The effects of stress concentration at contact points on coarse aggregates and means of reducing them should be thoroughly investigated. Through lab and field study, the impact of the aggregates strength, gradation and interlock will be studied. These findings will then be synthesized and incorporated in a step-by-step procedure to ensure quality of the final product laid down by TxDOT. The final product will also contain recommendations to modify the TxDOT specifications and test methods that would be necessary to construct durable and well-constructed pavements.

Research Products

- Modification of current criteria or development of new criteria for specifying coarse aggregates for use in HMA mixtures
- Guidelines for the development of HMA designs to minimize aggregate fracture
Abstract
In this project, the researchers will evaluate existing texture laser and the automated pavement surface distress imaging system to locate and measure loss of aggregate (raveling) and flushing during annual Pavement Management Information System (PMIS) data collection efforts. The researchers will create algorithms for each data set to analyze the effectiveness of the information. Once the algorithms have been verified on additional test sections, the researcher will create a Texas Modular Vehicle (TMV) compliant subsystem that will be installed and tested on a TxDOT data collection vehicle. TxDOT spends as much as $180 million to maintain 186,000 lane miles of roadway, and seal coats are a very important part of TxDOT's preventive maintenance program. The primary defects in seal coats and surface treatments are loss of aggregate, poor adhesion, streaking, and flushing. Current methods to determine performance indicators on seal coats such as aggregate loss and flushing are very subjective. The purpose of this project is to develop an accurate and rapid method to quantify the defects that may occur in the seal coat and the level of severity of these defects. Using the developed algorithm, the updated TMV will be able to have the following functions:
1. It will be able to detect and measure loss of aggregate and flushing while traveling at speeds of up to 70 miles per hour.
2. The developed algorithm will run on a single computer running the Linux operating system. All required hardware such as frame grabbers and data acquisition boards will be installed and functional.
3. It will acquire and process data from either or both the texture laser and the digital line scan images in real-time at highway speed.
4. The definitions for aggregate loss and flushing summaries will be defined and implemented in this subsystem as well as in PMIS. Definitions for severity levels will be established based on the subsystem's ability to perform aggregate loss and flushing measurements accurately and with repeatability.
5. The 0.1-mile summaries as well as the individual data elements will be sent to the host TMV computer using the required PF99 data format.

Research Products
- 3-D Scanning Laser System
- Software for embedded PC
- Database
- A user manual for the use of developed prototype device in the field
Abstract

TxDOT concrete pavement construction projects tend to include several types of transitions that consist of a variety of joint combinations and slab configurations. In many instances, the performance of the transition areas may become the focal area for maintenance dollars due to improper design that otherwise could have been avoided. Districts that regularly design and construct concrete pavements have developed standards and practices for some transitions and have learned from experience what the best practices are but for Districts that are interested in building more concrete pavements, these practices are not yet established. In this regard, information is needed to address the different types of issues that arise in every day design that in many cases depend on the support conditions, slab geometries, and the traffic levels expected over the service life. This project is intended to conduct a survey of TxDOT and other SHA practices and identify the best practices towards incorporating them in guidelines for design and construction of transitions areas that will enable TxDOT engineers and designers to avoid the pitfalls of bad practices. In addition to the guidelines, the project will also produce detailed design sheets to illustrate the specifics in the form of standard sheets for state wide implementation.
Abstract
Separation of longitudinal construction joints and uncontrolled longitudinal cracking in concrete pavements, have been observed since the 1970s in Texas. The separations and cracking provide an access for water to reach the base layer and cause deterioration. The water also causes corrosion of the steel and tie bars. The fracture of the steel leads to an edge loading condition which causes further distress to the pavement. As the cracks and separations widen, the ride quality is further decreased and a safety hazard to the traveling public can occur. Longitudinal separations are likely caused by corrosion or absence of tie bars, penetration of incompressible material into the joint, thermal contraction/expansion and construction errors. Longitudinal cracking is caused by one or more of the following: late saw cutting and insufficient saw cut depth, thermal contraction, and inadequate compaction beneath the longitudinal steel, non-uniform support of the base layer, inadequate reinforcement, and drying shrinkage. The repair of longitudinal separations and longitudinal cracks has generally utilized slotstitching, cross-stitching, and routing and sealing (primarily for cracking). TxDOT has made many repairs over the years but no research has been done to determine the effectiveness of different repairs. This study will survey districts to determine the extent of the problem, repair methods that have been used, and the performance of these repairs. Selected other states, paving contractors, and other experts will be consulted on the best methods to prevent and to repair these failures. Guidelines will be prepared and tested in field trials, and the results will be evaluated and modifications to the guidelines will be made as required. The final result will be guidelines, recommendations and specifications for repair and for new construction.

Research Products
- Guidelines for repair of longitudinal cracks and joint separations
- Specifications for longitudinal cracks and joint separations repair methods and materials
- Guidelines for construction of longitudinal joints
- Specifications and details for construction methods and materials dealing with longitudinal joints
Abstract
The Texas Department of Transportation (TxDOT) is the leader in the use of portland cement concrete (PCC) pavements in the US. They also developed a strong research program in the area of PCC pavement, making TxDOT one of the most innovative and proactive organizations when it comes to improving PCC pavement design and construction practices. One of TxDOT's achievements in the PCC pavement research area is the development of a comprehensive rigid pavement database. PCC pavements provide long-term performance with minimum maintenance required, if designed and built properly. It takes a long time for PCC pavements to show true behavior and how they eventually fail. Understanding how PCC pavements behave and eventually fail will enable engineers to improve the design, materials, and construction aspects of the PCC pavements. A long-term database is the best way to achieve this goal. The objective of this research study is to continue and improve previous work done for the current TxDOT Rigid Pavement Database (RPDB). A great effort has been conducted for over 30 years in the previous projects to collect and update rigid pavement data in Texas. This information has served as a basis for many other research projects on PCC pavements, thus, the findings from which helped to improve PCC pavement designs and specifications in TxDOT. This study will pursue several tasks that will enhance both the quality and quantity of the data collected for the RPDB. Some of the objectives of this project include:

1. Collection of data to calibrate the AASHTO mechanistic and empirical pavement design guide (MEPDG) developed under NCHRP 1-37A: This task will identify additional input and output variables needed to calibrate the MEPDG.
2. Restructuring RPDB: The current RPDB will be re-structured to take advantage of technological advances made in automation and database management areas. More specifically, the RPDB will be webbased, This will make the RPDB more accessible and valuable to TxDOT engineers.
3. Development of a user’s manual for the RPDB: This document will guide users of the database to perform various analyses with ease.
4. Documentation of special pavement sections: TxDOT has built numerous special PCC pavement sections. The details of the design, materials, construction, and performance of these sections need to be well documented, which will provide an accurate assessment of the performances. If the sections are proven to be effective in providing superior long-term performance, this documentation will facilitate further implementation of the special features of these sections.

Research Products
- Presentation of RPDB: will include new architecture and field data collected and added to database.
- RPDB User’s Guide. Will describe how to use the database and extract data
- Database analysis: this analysis will present preliminary findings from the performance data collected. TxDOT will request the type analysis to be conducted.
Abstract
Crack sealing and filling is one of the easiest and most common means of preventive maintenance. Properly installed crack sealant may extend pavement life by several years. However, crack sealant failure is common within the first three years of application. Sealant failure can be either adhesive or cohesive. Adhesive failure occurs at the interface between sealant and asphalt concrete crack walls; instead, the cohesive failure is referred to as the crack within sealant itself. Actually, both adhesive and cohesive failures mainly caused by thermal movement of cracks can be simultaneously simulated by the upgraded Overlay Tester developed under TxDOT research project 0-4467. Thus, the objective of this research is to evaluate the Overlay Tester device for use in testing asphalt crack sealants for adhesion and elasticity during thermal cycles on Hot Mix Asphalt Concrete (HMAC) cracks. These two properties are believed to have been the major failure points resulting in variable field performance throughout the state for both hot and cold pour products. This is a two-phase research project. Phase I will focus on the feasibility of using the Overlay Tester to evaluate crack sealants. Repeatability and reliability of the Overlay Tester to evaluate crack sealants will be determined in the Phase I. If the device shows promising results, then Phase II will complete the development of the test procedures and draft specification for these materials.
Abstract
The objective of this project is to develop a Successful Flexible Pavements Database populated with data from experimental and non-experimental successful pavement sections. The scope of the project includes defining and identifying successful pavement sections. A select group of sections meeting this definition will be identified through a multi-step selection process for deeper investigation, similar to that performed during standard forensic pavement investigations. Statistically sound methodology will be employed to optimize both data collection and selection of sections for deeper investigation. All collected information will be analyzed to better understand the factors which increase likelihood of pavement's successful performance. Strategies will be developed to keep the Successful Flexible Pavements Database up-to-date over time.

Program Coordinator
Darrin Grenfell, FHWA

Project Director
Ahmed Eltahan, CST

Project Advisors
Andrew Wimsatt, FTW
Dar-Hao Chen, CST
Darlene Goehl, BRY
Gary Graham, CST
Joe Graff, MNT
Joe Leidy, CST
Joe Schaunaman, LBB
Karen VanHooser, ISD
Magdy Mikhail, CST
Mike Murphy, CST
Tracy Cumby, LBB
Walter Torres, HOU
William (Bill) Brudnick, HOU

Research Supervisor
Paul Krugler, TTI

Research Products
• Final-Draft Definitions of Criteria to Identify Successful Flexible Pavements and Successful Experimental Projects
• Conceptual Model for the Development of the Successful Flexible Pavements Database
• List of Tier-One Sites and Summary of Data and Information Supporting Selection
• Draft/Beta Version of the Successful Flexible Pavements Database
• List of Tier-Two Sites and Summary of Data and Information Supporting Selection
• On-Line Successful Flexible Pavements Database
• Recommendations on Changes to Specifications to Improve Pavement Performance
• Recommendations on Changes to Testing Techniques to Improve Pavement Evaluation
• Strategies for Information Update
• PowerPoint Presentation to Summarize Conclusions and Recommendations

Research Universities and FY 2006 Budget
Texas Transportation Institute - $169,938

Total Project Budget
$353,033
The difficulties facing pavement engineers who consider using Portland cement concrete (PCC) overlays over hot mix asphalt concrete (HMAC) are:

1. Is the HMAC section in need of rehabilitation a good candidate for PCC overlay?
2. If it is, what should be the optimum PCC overlay structure, thin whitetopping (TWT) or full depth regular PCC pavement?

To get answers to these questions, it is important to be able to properly evaluate the existing HMAC pavement for its ability to uniformly support PCC slabs. Without the ability to properly evaluate the supporting capability of HMAC pavement, it's difficult to develop reasonable rehabilitation strategies. As described in the project statement, TxDOT developed design standards and special specification for thin white topping. However, TxDOT currently does not have guidelines or procedures for the rehabilitation of HMAC showing rutting and shoving, with TWT.

Even though AC overlay is not included in the project statement as an option to be explored in this study, during the preproposal meeting, the PD indicated that AC overlay should be an option for the overlay to be investigated.

This research project is to develop guidelines and design procedures for the PCC overlay or AC overlay in consideration of life cycle cost analysis for statewide implementation. If successful, the products of this project will enhance TxDOT engineer's ability to develop the most cost effective rehabilitation strategies for distressed HMAC pavement.

**Research Products**

- Procedures to determine optimal design life & thickness of PCC overlay through LCC analysis
- Guidelines to determine if TWT &/or full depth PCC pavement are viable options
- Modified design procedures for TWT & full depth PCC pavement
- Modified standards & specifications for TWT & full depth PCC pavement, if needed

**Research Universities and FY 2006 Budget**

Center for Transportation Research - $103,119

**Total Project Budget**

$203,119
Abstract

This project was initiated to expand on and apply the database and software developments conducted under Texas Department of Transportation (TxDOT) inter-agency contracts and Federal Highway Administration (FHWA) Pathfinder studies towards tracking and analyzing the performance of hot-mix asphalt (HMA) mixtures in Texas. Previous developments focused on linking Design and Construction Information System (DCIS) and Pavement Management Information System (PMIS) data. Project letting information imported from the DCIS is used to identify routes in Texas on which specific asphalt mixtures are paved. The performance of these mixtures is then tracked from PMIS records. This proposal outlines a strategy for upgrading and implementing the current procedures towards network level analysis of asphalt mixture performance. Aspects addressed include the development of a computer software package with a web-browser-based interface incorporating Geographical Information System (GIS) software with enhanced query and reporting features. A strategy to better address traffic wheel loads and axle type characterization is proposed to enhance the integrity of performance evaluations. The final product of the proposed research will serve as a pavement management tool to optimize asphalt mixture performance.

Research Products

- Computer Software Package that: (1) Allows users to automate the collection of historical lettings and performance data; (2) Includes analysis procedures that analyzes historical data for HMA projects in Texas and summarizes benefits and (Cont"d below)

- User's Manual

Research Universities and FY 2006 Budget
Center for Transportation Research - $99,955

Total Project Budget
$199,289
Abstract
To develop, validate and calibrate any pavement design and rehabilitation method, reliable databases are essential. These databases should include material properties, pavement structural characteristics, highway traffic information, environmental conditions, and performance data, such as cracking, rutting, roughness, etc. In principle, these databases are currently available in Texas; however, they have been designed and maintained with specific objectives, not necessarily keeping in mind their potential use for pavement design. Specifically some of these databases have been designed for network level applications, not to calibrate data intensive performance models such as those typical of mechanistic-empirical design models. The goal of this project is to develop a flexible pavement database. In order to achieve this goal the following tasks will be undertaken: (i) to draft a plan for the development of a sustainable database, (ii) development of the database structures for uploading the required data and (iii) to initiate the population of the database with the objective of carrying out local calibration of FPS-19W and the new M-E Design Guide. This integrated database will be designed will the goal of developing, validating and calibrating mechanistic-empirical flexible pavement design models, a project-level application. As such, it will interact with and complement the existing Pavement Management Information System (PMIS), which is a network-level application.

Research Products
- Web-based Database
- Strategic Plan for Management of Database

Research Universities and FY 2006 Budget
Center for Transportation Research - $140,000

Total Project Budget
$450,000

Program Coordinator
Joe Graff, MNT

Project Director
Ahmed Eltahan, CST

Project Advisors
Craig Cox, CST
Dar-Hao Chen, CST
Joe Leidy, CST
John Bilyeu, CST
Karen VanHooser, ISD
Luis Peralez, PHR
Magdy Mikhail, CST
Mark McDaniel, CST
Mike Murphy, CST

Research Supervisor
Jorge Prozzi, CTR
RMC 1
Continuing Projects
**Abstract**

The ultimate goal of this study is to evaluate geotextiles placed under or within a hot mix asphalt (HMA) overlay to reduce the severity or delay the appearance of reflection cracks. For purposes of this study, "geotextiles" are defined as geo-fabrics, geo-grids, and geo-composites. Specific activities to achieve the project goals are:

- Conduct a review of published information to determine which geotextiles have performed successfully and unsuccessfully,
- Interview knowledgeable individuals to identify problems and needs specific to TxDOT and collect current unpublished information,
- Evaluate geotextiles in a logical sequence of laboratory tests,
- Use appropriate mathematical models to conduct comparative evaluations of pavements with and without different geotextiles in different conditions of substrate, traffic, and climate,
- Design and assist in installation of test pavements to evaluate geotextiles in the two applications of interest,
- Prepare guidelines for selecting the optimum geotextile for overlay applications,
- Prepare meaningful specifications for geotextiles for overlay applications, and
- Prepare final report and summary reports.

---

**Program Coordinator**
German Claros, RTI

**Project Director**
(Vacant Position)

**Research Supervisor**
Joe Button, TTI

---

**Research Universities and FY 2006 Budget**
Texas Transportation Institute - $80,000

**Total Project Budget**
$280,000
Abstract

Good ride quality, proper cross slope, and accurate material estimates are important for an overlay project. Currently there is not a method in Texas to accurately relate the condition of an existing roadway with the potential benefits of different overlay and milling strategies during the design phase or provide the appropriate information to the contractor. Many Districts have requested the use of the TxDOT inertial profilers to locate and measure potential grind and fill areas on paving projects prior to overlays. The Districts want to use a high-speed accurate instrument to survey the existing roadway without disrupting traffic. Inertial profiles alone do not provide sufficient information to perform this task. During project 0-1782, a scanning laser system was used for obtaining transverse profile for rut measurements. This research will investigate the integration of the scanning laser system and the inertial profiler for overlay and milling strategies.

Research Products

- A measurement system that can provide cross slope measurements
- Software package for 3D Display and Analysis in accordance with work plan
- User's Manual for P2 Software Package

Program Coordinator
John Rantz, LBB

Project Director
Brian Michalk, CST

Project Advisors
Gary Graham, CST
Karl Bednarz, SJT

Research Supervisor
Roger Walker, UTA

Research Universities and FY 2006 Budget
Texas Transportation Institute - $50,068
University of Texas at Arlington - $61,325

Total Project Budget
$448,351
Abstract
The objective of this project is to develop a forensic pavement knowledge management system (KMS) for the Texas Department of Transportation (TxDOT) within its new Learning Content Management System (LCMS). The KMS is to serve the immediate and future needs of TxDOT's pavement community and, as it will be the initial KMS within TxDOT, set the stage for application of knowledge management principles throughout the organization. The scope of the project includes identifying sources of valuable forensic pavement knowledge; developing methodology for capturing that knowledge through interviewing, systematic classification and codification; transferring that content to the TxDOT LCMS; making related forensic pavement data and information sources available to the LCMS user; developing a framework for maintaining and systematically updating KMS content; and marketing this pilot system throughout TxDOT's pavement community and beyond.

Research Products
- Marketing Strategy for the Forensic Pavement Knowledge Management System
- Promotion Document for Distribution at the End of Phase One
- Forensic Rigid Pavement Knowledge Management System Prototype (utilizing LCMS platform)
- Content for the Forensic Rigid Pavement Knowledge Management System (utilizing LCMS platform)
- Content for the Forensic Flexible Pavement Knowledge Management System (utilizing LCMS platform)
- PowerPoint Presentation to Market the FPKMS
- Forensic Rigid Pavement Knowledge Management Approach (utilizing LCMS platform)
Abstract
Project 0-4524 will be a three-year study of the application of surface energy measurements to evaluate moisture susceptibility of asphalt and aggregates. The project is divided into two phases, the first of which is to validate the methodology that has been developed at the Texas Transportation Institute to identify those combinations of asphalt and aggregate which will be susceptible to moisture damage in service. The second phase is to determine the efficacy of selected anti-strip agents; determine the impact on moisture susceptibility to various material factors which alter the surface energy components of the aggregate, asphalt, and the water; develop catalogues of the relevant properties of commonly used aggregates and asphalts and the effects of the material factors on them, and to develop testing protocols, draft materials specifications, and testing equipment specifications to permit the implementation of the developed technology within the Texas DOT.

Research Products
- Draft specification for surface energy measurements for aggregates and for asphalts
- Draft specifications for the required testing equipment for surface energy measurements
- Implementation Plan to implement the technology in the TxDOT including training courses

Research Universities and FY 2006 Budget
Texas Transportation Institute - $170,000

Total Project Budget
$540,000
Abstract
The use of Comprehensive Development Agreements (CDA) by the Texas Department of Transportation could revolutionize the manner in which large transportation projects are executed. TxDOT’s Texas Turnpike Authority Division and Lone Star Infrastructure are pioneering the use of CDA for construction of State Highway 130, a tolled relief route east of Austin. The SH 130 project represents a great opportunity for TxDOT, the engineering and construction industries, and the engineering education community, to benefit from the numerous innovative approaches that will be applied on the project. This research project will capitalize thoroughly and effectively on this opportunity by focusing on assessment of the CDA arrangement and tracking of benefits, successes, and associated lessons learned. Specific components of the effort include a performance benchmarking program, a computerized lessons-learned system, and analyses of contractual and communication process innovations.

Research Products
- Documentation of the SH 130 organizational structure, first version.
- Documentation of the SH 130 organizational structure, final version.
- Benchmarking methodology for comparing CDA contracts to conventional projects.
- Lessons learned database with brief, user-friendly system users manual.
- Annual SH 130 Innovations Workshop.

Program Coordinator
(Vacant Position)

Project Director
Timothy Weight, AUS

Project Advisors
Jeff Curren, HDR
Robert Stone, TTA

Research Supervisor
James O'Connor, CTR

Project - 04661
Monitoring and Evaluation of SH 130
Project Construction
Start Date - 09/01/2003
End Date - 03/31/2008

Research Universities and FY 2006 Budget
Center for Transportation Research - $160,000

Total Project Budget
$645,000
Abstract
Texas Department of Transportation (TxDOT) research project 0-4047 evaluated the current TxDOT Binder Quality Assurance Program and assessed any recommended changes. Several binder properties such as Dynamic Shear Rheometer (DSR) test results ($G^*/\sin\alpha$) has been identified as the quality assurance parameter. Based on the findings of this research, a further development of binder quality assurance program is needed before implementation. Development of a statistically based quality assurance program is the main objective of this research. The researchers will investigate several related issues to develop such a program. Some of these issues are sampling and testing protocol, setting up acceptance criteria and limits, and addressing the dispute resolution. The widely suspected discrepancies between the properties of asphalt at the construction project site and asphalt manufacturer's plant will be investigated by collecting field samples. This part of the investigation will serve as the preliminary database for statistical analysis and also help in the development of sampling and testing protocol. In order to split the responsibility between the two entities (producer and construction contractor) on the seller end, a two-stage quality control / quality assurance (QC/QA) program would be developed. The QC/QA plan at the asphalt manufacturer's plant would help TxDOT for the pre-qualification purpose. On the other hand, the QC/QA program at the construction job site may lead into an implementation of a management practice to assure quality or may result in further research to address the inadequate specification requirement. A forensic investigation will be performed to select the appropriate strategy at the construction job site.

Research Products
- Binder quality control and quality assurance program at the binder plant.
Abstract
In Project 0-4687 "Rubblization and Crack and Seat as Major Rehabilitation for Concrete Pavements" it is proposed to review and assemble all of the relevant pavement design recommendations and pavement performance information from national and international highway agencies. This information will be used to develop guidelines on how to conduct site investigations to determine if slab fracturing plus an overlay is an appropriate treatment for individual sections of concrete pavement. For those projects identified as good candidates, decision criteria will be developed to select which fracturing technique is optimal. For each fracturing technique, this project will provide TxDOT with construction specifications, overlay mix selection criteria and structural design recommendations. In evaluating current performance it will be critical to draw upon the lessons learned for projects already completed in Texas and other states such as Louisiana, Arkansas and Georgia which have embarked on extensive concrete pavement rehabilitation programs. To implement the findings of this study the recommendations will be applied to two actual TxDOT highway rehabilitation projects. The research team will work with the District staff to test the original section to make sure it is a good candidate, to assist with structural design of the HMA surfacing, and to provide technical support during construction. Several training courses will also be taught around the State to instruct district personnel on the project findings and recommendations.

Project - 0-4687
Rubblization and Crack & Seat as Major Rehabilitation for Concrete Pavements

Start Date - 09/01/2004
End Date - 08/31/2007

Program Coordinator
(Vacant Position)

Project Director
Darlene Goehl, BRY

Project Advisors
Andrew Wimsatt, FTW
Leo Betancourt, ELP
Susan Chu, BMT
William (Bill) Willeford, TYL

Research Supervisor
Tom Scullion, TTI

Research Products
• Forensic Investigation Plan and results of literature search
• Decision criteria for selection either Rubblization or C/S and pavement evaluation procedure
• Non-Invasive test procedure
• Improved pavement type selection process
• Thickness design procedure
• Mix Design and Construction Guidelines

Research Universities and FY 2006 Budget
Texas Transportation Institute - $119,695

Total Project Budget
$353,030
Abstract
With the increasing use of modified asphalt binders there is a great need for methods that can evaluate the effectiveness of modifiers, including variables such as modifier content and composition of the base asphalt, and for specifications that are applicable to these materials. The proposed work will address these needs by: studies of current polymer modified binders and their base materials to determine their effectiveness; studies of the extent to which polymer effectiveness is lost due to binder oxidation; studies to correlate laboratory aging methods to field aging; recommendation of an aging test protocol, test procedure, binder criterion that correlates to failure on the road; and specification for testing an aged binder as an indication of ultimate failure of the binder after aging. The results of this research will provide needed information for evaluating the ability of polymer modifiers to extend the service life of a pavement binder and thus for determining a polymer's cost effectiveness. The results will also be useful for evaluating in-service pavements that contain either unmodified and polymer modified binders to estimate their remaining life. Such estimates will be valuable to the scheduling of maintenance and rehabilitation dollars and resources.
Abstract
The Texas Department of Transportation (TxDOT) needs a smoothness specification for surface-treated pavements. To address this need, Phase I of Project 0-4760 will initially investigate the applicability of using inertial profilers to measure the smoothness of flexible base surfaces. If the findings indicate that base texture does not detract from the collection of repeatable and accurate profile measurements, work will continue on drafting a smoothness specification for surface-treated roads. Development work is expected to include the following:
• Collection of profile measurements before and after placement of surface treatments on TxDOT projects;
• Evaluation of change in smoothness due to surface treatments based on field data; and
• Assessment of the applicability of current quality assurance tests for acceptance testing of flexible base smoothness.

The draft smoothness specification may follow a similar format as the current ride specification (SS 5880 or Item 585), or a simpler format where the base smoothness is either approved or disapproved. The initial specification will be pilot tested on a number of projects towards the end of Phase I. In Phase II, a cross-slope specification for flexible base will be developed and added to the ride quality specification, should TxDOT decide to continue Project 0-4760.
Abstract

On March 29th, 2001 a memorandum was sent to all District engineers providing guidance on the design of pavements when more than 30 million ESAL’s are exceeded. This guidance was developed by the Flexible Pavement Design Task Force whose objective was to develop new asphalt concrete specifications and pavement designs that could meet the demands of heavy truck traffic. A suggested typical section was prescribed similar to the perpetual pavement concept developed by the Asphalt Institute. Thirty-three high truck use routes were listed in the memorandum. When a district proposes to use an asphalt concrete pavement on these routes it is the "expressed intent" of the Task Force to use the SMA / Stone Filled hot mix and suggested typical section. Since publication, three Districts have constructed sections using these pavement concepts. The Waco District constructed a section on IH 35, the Laredo District built a section on IH 35 near Cotulla in Lasalle County, and Fort Worth is currently constructing a section on SH 114. The goal of Study 4822 is to monitor the performance of the existing projects, to test the materials in the field and laboratory and to identify the lessons learned for these initial projects in order to improve future full-depth designs. The purpose of this study as stated in the Problem Statement is as follows:

1. To validate the full-depth pavement design concept by relating field and laboratory results to pavement performance monitored after construction,
2. To create a database of design parameters for the current FPS design system and the NCHRP 1-37A mechanistic design process and the Asphalt Alliance design methodology, and
3. To use the data collected to verify and enhance TxDOT's design, materials and construction specifications.

Research Products

- Users Manual for Data Base
- Database on materials properties and performance data
- Half day workshop on full depth design procedures: Notes and Materials
- Gyratory Compaction equipment for field trailer
- Preliminary design guide for full depth pavement
- Revised design guide for full depth pavement

Research Universities and FY 2006 Budget
Texas Transportation Institute - $174,394

Total Project Budget
$906,370
Abstract

To achieve specified PG grades, refineries make use of modifiers to enhance the properties of neat asphalt. Even though modified binders may pass PG specifications, some perform better than others. To make sure that poor performing modifiers are not used, TxDOT has specified the Elastic Recovery test (Tex-539-C). However, success of this test in eliminating poor performing binder is unknown at this point and needs to be evaluated further. To implement the AASHTO 2002 Pavement Design guide (TxDOT is the lead state for implementation) and to take advantage of the Superpave Gyratory Compactor (SGC), TxDOT needs to move mix design from the Texas Gyratory Compactor (TGC) to the SGC and measure material properties that can be used for calibration of performance models for Texas environmental conditions. TxDOT has already sponsored two projects 0-4423 (to replace the TGC) and 0-4468 to measure material properties for the AASHTO 2002 design guide. However, the focus of these projects is to only evaluate asphalt concrete (AC) mixes consisting of unmodified binders. Since improvement in performance of asphalt concrete mixes depends on type of modifier and mix design, it is essential that the AC mixes consisting of modified binders be evaluated as well. Therefore, the second objective of this study is to perform mechanical testing in the laboratory to evaluate the rutting and fatigue potential of AC mixes consisting of modified binders. The abundance of information developed at the end of 0-4423, 0-4468, and this project will make selection of appropriate AC mixes an extremely difficult process. To assist mix designers in making informed decisions, guidelines for selection of AC mixes need to be developed. Therefore, the final objective of this study is to integrate information gathered in these projects towards the development of these guidelines.

Research Products

- Guidelines for the selection of Mixes
- Computer Expert System
- Microsoft Access Database for AASHTO 2002 Material Properties
- Workshop Material in Power Point
- Comparative Analysis between Modified and Common ACP Mixtures in Terms of Fatigue and Rutting

Program Coordinator
Elias Rmeili, BWD

Project Director
Magdy Mikhail, CST

Project Advisors
Brian Crawford, ABL
Darlene Goehl, BRY
Jerry Peterson, CST
Richard Izzo, CST

Research Supervisor
Vivek Tandon, UTEP

Research Universities and FY 2006 Budget
Center for Transportation Research - $24,344
University Of Texas At El Paso - $20,768

Total Project Budget
$315,112
Abstract
TxDOT has used gravel aggregates for many years in the construction CRC pavement but these pavements in many instances have been subject to delamination and spalling distress which has been very expensive to maintain and repair. Nonetheless, there is interest in gaining a better understanding of the construction practices necessary to successfully use gravel in concrete paving. One possibility is the use of crushed gravel to improve the concrete’s resistance to delamination but this proposal contains several unique features to investigate the effect of such measures such as surface energy measurements, shape and texture imaging, and use of NDT to detect delamination.
Abstract

Base reinforcement results from the addition of a geosynthetic at the bottom or within a base course to increase the structural or load-carrying capacity of a pavement system. While there is clear evidence that geosynthetic reinforcements can lead to improved pavement performance, the identification and quantification of the parameters that contribute to such improvement has remained, at best, unclear. Accordingly, the overall goals of this research include: (i) determining the properties of geosynthetics used in unbound bases that contribute to enhancing the performance of pavement systems, and (ii) developing material specifications based on geosynthetic properties or on a combination of geosynthetic and material properties. Pavement structures deteriorate under the combined effects of traffic loading and environmental conditions (e.g., soil expansion or shrinkage due to moisture changes). The proposed research will assess both aspects: effect of geosynthetics on the pavement structural section and its resistance to environmental changes. Accordingly, the Work Plan has been carefully tailored to account for the conditions that are typical to TxDOT pavements and to Texas environmental conditions. The specific activities to be accomplished in this research include: (i) compiling available information on the design, construction, and performance of geosynthetic-reinforced base courses; (ii) conducting laboratory and field testing programs to quantify the performance of geosynthetic-reinforced base courses constructed by TxDOT; and (iii) tailoring design methodologies and developing specifications to meet future TxDOT needs regarding the use of geosynthetics for unbound base courses. Implementation of the findings of this research will be enhanced by the development of a pilot short course.

Research Products

- Design guidelines for geosynthetic-reinforced base courses
- Draft material specifications
- Draft construction specifications
- Short course for TxDOT personnel on use of geogrids for reinforcement of unbound base courses
Abstract
The use of Open Graded Friction Course (OGFC) mixes have many safety benefits that are of interest to transportation engineering. However, the early OGFC mixes had problems in terms of lack of durability and concerns with winter performance and maintenance issues, which caused discontinued use of the mixes. With changes in open-graded mixture technology in the past decade, there has been increased interest in the use of New Generation Open Graded Friction Courses (NGOGFC), or Permeable Friction Courses (PFC). These second generation OGFCs are more open-graded, have increased air void structures, have more asphalt, and are enhanced with polymer asphalt, rubber asphalt, and fiber additives. The design of the NGOGFC has reduced some of the durability problems associated with the first generation OGFC. However, it is unclear whether or not advances in NGOGFC technology will solve the problems with performance in winter conditions. These open mixes may still allow accumulations of moisture through rain, snow, or sleet, and during rapid freezing events, "black ice" can be produced, which can be a very dangerous condition for vehicles traveling at imprudent speeds or with improper tire inflation or tread depth. Some of the North Texas areas have reported that these mixes are "the first to freeze and the last to thaw" and are therefore problematic during rapidly advancing freeze conditions and especially during rapid freeze/thaw cycles. Many regions prone to snow or ice have not considered using PFCs due to potential winter problems, but some countries in Europe have established winter maintenance programs to address these potential safety concerns, programs which have been implemented in some states in the U.S. These situations should be examined, and once the mechanism associated with formation of the "black ice" phenomena has been established, a laboratory study can be initiated to determine if these problems can be replicated in a laboratory setting, and if so, whether a remedial or preventative strategy can be developed. The new "i-Button" embeddable sensor technology, developed under research project 0-1700, will be instrumental in monitoring temperature profiles and identifying possible icing conditions during the proposed lab and field work.

Research Products
• Literature synthesis
• District questionnaire results
• Field measurements
• Preliminary guidelines for cold-weather NGOGFC
• Results from laboratory OGFC testing
• Final guidelines on where to construct PFC layers for cold-weather NGOGFC

Research Universities and FY 2006 Budget
Center for Transportation Research - $110,000

Total Project Budget
$229,833
Abstract

The Texas Department of Transportation (TxDOT) is implementing a new smoothness specification based on surface profiles. The new specification includes pay adjustments that are based primarily on measuring the ride quality achieved from construction. However, it is not certain whether the improvement in ride quality translates to increased service life. Since the new specification is based primarily on ride quality, a question to ask is, "Are there profile components not accounted for that might be detrimental to pavement life based on dynamic loading criteria?" The proposed project aims to answer this question by investigating the relationship between surface roughness and truck dynamic loads to establish criteria for pavement smoothness that incorporate both ride quality and truck damage criteria. The research to be performed is expected to cover the following tasks:

- A field test program to measure surface profiles and vehicle dynamic loads for different levels of roughness;
- Modeling of dynamic loads for a range of common truck configurations;
- Investigating the relationship between truck dynamic loading and pavement life;
- Establishing a plan for long-term field monitoring of pavement sections to verify research findings; and
- Development of a draft ride specification that incorporates ride and truck damage criteria.

Research Products

- Revised methodology for detecting localized roughness. Draft document explaining the methodology and presenting algorithms for evaluating localized roughness based on new criteria.
- Draft smoothness specification. Draft document of a smoothness specification incorporating both ride quality and dynamic load criteria.
- Long-term field monitoring plan
- Vehicle transfer functions for dynamic load prediction
Abstract

This project was initiated to address a number of issues relating to the use and performance of home made and containerized patching maintenance mixtures for repairs in cold and wet weather. The Texas Department of Transportation (TxDOT) reports problems relating to the durability, workability, and storageability of home made patching mixtures under these conditions. The Department is thus requiring an improved mix design procedure to develop patching mixtures with a durability of at least six months that accounts for traffic volume. Furthermore, current TxDOT material specifications for containerized patching mixtures have restricted the use of affordable alternatives and possible revisions to the specifications could promote competitiveness and lower costs. The proposal outlines procedures for (1) the mix design of home made mixes, (2) laboratory tests to better evaluate the workability and stability of patching materials and to identify performance criteria, (3) a methodology to undertake benefit cost analysis in determining optimum performance, and (4) a program for field performance evaluations. Central to the proposed procedure is an experimental program to evaluate the performance of patching materials by investigating the influence of pertinent material characteristics, including gradation, aggregate type, binder viscosity and content, and specifically type of admixture. The experiment is designed to delineate the characteristics appropriate for patching materials on low, moderate, and high volume roads.

Research Products

- Specification for containerized cold mixes
- Field Manual for mix design procedure and specifications
- Recommendations for performance testing
- Recommendations for selecting appropriate containers

Program Coordinator
Joe Graff, MNT

Project Director
Tracy Cumby, LBB

Project Advisors
Dale Rand, CST
Richard Izzo, CST
Stevan Perez, LBB

Research Supervisor
Jorge Prozzi, CTR

Research Universities and FY 2006 Budget
Center for Transportation Research - $108,984

Total Project Budget
$214,271
Abstract
Thin pavement overlays, either of asphalt concrete (AC) or portland cement concrete pavement (PCCP) constructed on top of continuously reinforced concrete pavement (CRCP) are cost-effective rehabilitation strategies that, when properly designed and placed, provide an optimum utilization of the qualities of the existing pavement. Overlays can provide an assortment of benefits, depending on the specific type of overlay, material, original pavement condition, and thickness. In general, overlays protect the existing infrastructure by optimizing the use of its remaining life, extend the life of the existing pavement, protect the structure against deleterious environmental effects, expedite construction, minimize clearance problems, and improve the ride quality, while remaining a relatively low-cost rehabilitation strategy.

Other rehabilitation strategies (for instance, unbonded concrete overlays or full-depth replacements) do not make such an optimal use of the existing pavement. Because more service life is added to the existing structure, AC overlays and BCOs are means to protect that investment for the benefit of the owners and users of the facility.

The type of overlays subject to this study are thin, therefore, potential clearance problems with bridges and other existing structures are minimized. Overlays work as a barrier to prevent intrusion of moisture and other extraneous elements into the structure, and insulate it from adverse environmental effects, protecting the structure and making it last longer. There is anecdotal evidence that thin overlays provide a much higher level of extended service to old concrete pavements than would be predicted by theoretical models. This means that we do not yet fully understand this complex mechanism, and therefore need to study it more discretely. Several postulations indicate reduced dynamic loadings; environmental or temperature insulation, and reduced moisture intrusion contribute greatly to this phenomenon. There can be overlap between the applicability and functionalities of an AC overlay and a BCO; in other words, for some cases both types of overlays may be feasible and may provide the desired benefits. In these cases, the decision will be determined by evaluating which strategy provides the best economical solution in terms of a life cycle cost analysis.
Abstract
Fog and rejuvenating seals have the potential to reduce and reverse the aging of asphalt pavements, reduce cracking and raveling, and provide a better, longer-lasting pavement. Pavements sealed within the last few years and new treatments will be tested each year of the 2-year study to determine the impact of these treatments on permeability, strength, binder viscosity, and depth of penetration. Guidelines on the best practices, selecting appropriate candidates, pre-treatment work, application rate and treatment type, application suggestions, curing time, and performance will be summarized in a small, pocket sized pamphlet that will be easy to carry, will be provided.
Abstract

Early-age evaporation from the surface of a concrete pavement, if not properly controlled, may induce undesirable effects that negatively impact long-term performance. Early-age behavior such as slab curling, warping, delamination, loss of strength, close cracking, and even plastic shrinkage cracking are affected by the amount of evaporation and the effectiveness of the curing medium. TxDOT has recently experienced cases of spalling and delamination failures that may be related to high evaporation rate under extreme field conditions, such as high temperature, low humidity, and strong wind. Relative humidity measurements taken during the curing stages of concrete pavement construction under Project 1700 have also shown that in some cases the curing membranes are not effective in controlling water loss under high evaporation conditions. The rate of evaporation is a key item relative to monitoring the quality of the curing. However, the TxDOT standard specifications for pavement construction (Item 526) only defines the use of the membrane curing in terms of key characteristics such as percent solids, density, viscosity, and color and even specifies the rate of coverage to not be less than one gallon per 180 square feet of surface area but fails to specify curing performance or limits on the rate of evaporation. Therefore, a research study is needed to investigate curing membrane effectiveness in controlling evaporation under actual field conditions. The purpose of this study is to evaluate the effectiveness of curing membranes in controlling evaporation under field conditions. To achieve the goal of this project, various studies will be performed. First, existing information will be reviewed including research studies from other states and countries and recent curing membrane research data from Research Project 1700. Based on the findings from previous research, problem areas will be identified and initial recommendations for revised specifications will be made. Then, laboratory testing will be conducted using selected relative humidity measuring sensors, comparing devices that can be used in the field and laboratory to weight loss using a scale. A field experimental plan will be developed and the testing will be performed to measure the relative humidity and other relevant variables under different curing conditions. Based on the laboratory and field testing results, the most effective curing membranes will be ranked. The effect of delaying the application of the curing membranes will also be investigated. Finally, laboratory test procedures will be developed for TxDOT use to field rank curing compounds in the laboratory. This will lead to draft specifications for curing membranes.

Research Products

- Literature review synthesis on curing compound experience
- Short-term recommendations to specifications
- Effect of delaying curing membrane application
- Laboratory test procedures for evaluating curing compounds
- Draft specifications
- Ranking of most effective curing membranes and techniques
Abstract
Selecting the appropriate overlay thickness and the combination of aggregates and binder types are important decisions that TxDOT engineers make on a routine basis. However, this selection is a difficult balancing act. To perform well in the field the HMA overlay must have a balance of both good rut and crack resistance, also it must have sufficient thickness to withstand the traffic loads and environmental conditions. TxDOT already has the Hamburg wheel tracking device (HWTD) to screen out mixtures that are susceptible to rutting. Meanwhile, a new device, the upgraded overlay tester, has been developed for TxDOT engineers to characterize the reflection cracking resistance of asphalt mixtures. Therefore, the primary goal of this research is to develop and recommend a process to integrate the upgraded overlay tester into TxDOT’s current mixture design system. The secondary goal is to develop a HMA overlay thickness design methodology and provide a material selection guide for District use. Finally, the overlay selection and design procedure will be pilot tested, validated, and enhanced through building experimental sections and monitoring their rutting and reflection cracking performance.

Research Products
- Integrated asphalt overlay mixture design system
- Guidelines for characterizing existing pavements for HMA overlay design
- Advanced asphalt overlay thickness design system
- Guidelines on selecting combinations for different layers
- Criteria for selection of asphalt overlay

Research Universities and FY 2006 Budget
Texas Transportation Institute - $128,605

Total Project Budget
$383,443
Abstract
The Texas Department of Transportation (TxDOT) has established Hamburg Wheel Tracking Device (HWTD) specification criteria for Superpave mixtures. This has introduced a performance related feature to an otherwise volumetric mix design approach structured to ensure the rutting performance of asphalt mixtures. The Superpave mixture design procedure is itself geared towards the production of rut resistant mixtures. This, together with the new HWTD performance criterion tends to promote mixtures with lower binder contents. While this is advantageous for rutting resistance, there are reports 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, TxDOT has investigated the possibility of modifying the current design criteria established for Superpave mixtures. Initial research investigating the influence of lowering the 4 percent voids in the mix criterion to 3 and even 2.5 percent has resulted in increased optimum binder contents but has proven detrimental for those mixtures using softer binders, albeit that research findings from the NCAT test track indicate that more asphalt could be placed into mixtures that have highly polymer-modified binders. The Superpave mixture design method does not account for mixes with extremely stiff polymer-modified asphalts currently being used. Furthermore, the concentration of coarse aggregate in the mix and the influence of nominal maximum aggregate size are not accounted for. The research proposal outlines a mixture design procedure based on a performance related approach geared towards determining revised Ndesign compaction levels to increase binder contents in asphalt mixtures without compromising rutting performance. An extensive experimental program has been devised to investigate the performance characteristics of asphalt mixtures designed using the revised Ndesign levels and to account for the nominal maximum aggregate size and the concentration of coarse aggregate in the mix. Methods to adjust the VMA requirements of mixes based on aggregate type and gradation will be investigated as part of the proposed procedure.

Research Products
- Guidelines for selection of N-design and adjustment of VMA specifications
- Guidelines for adjusting N-design as a function of traffic and environment
- Criteria for design and selection of Superpave mixes
- Database containing all test results
TxDOT has used the conventional impact hammer laboratory compaction methods in Test Methods Tex-113-E and Tex-114-E for decades to develop moisture density relationships and prepare soil and base specimens for mechanical testing. While simple to perform, this lab compaction technique can be subject to significant variances from both the equipment and operator. In addition, concerns have arisen that TxDOT specifies too low compaction effort for current field equipment. Furthermore, spatial variability and unrepresentative soil fabric can result from lab impact hammer compaction, resulting in lab results that do not adequately correlate with true field performance. Given the concerns and problems with the existing lab compaction methods, this project will evaluate ways to improve the precision of the existing technique, evaluate the impact on mechanical properties of increased lab compaction effort, and assess the potential of alternative lab compaction techniques to improve the correlation between laboratory results and field performance.

**Research Products**
- Conclusions and Recommendations concerning Tex-113-E and Tex-114-E
- Evaluation of lab techniques that result in variance between lab and field compaction
- Evaluation of materials/tests that are more likely to exhibit errors
- Recommended methods for minimizing effects of lab preparation on testing
- Recommended test methods and/or specifications for improved correlation between lab and field compaction
Abstract

It is common practice for TxDOT to construct surface treatments (1-, 2- or 3-course) directly over base courses. Such surface treatments may act as either wearing surfaces or underseals. There are also many other states that use surface treatments directly over base. The decision to use surface treatments is based on a number of factors including low life-cycle cost, low initial construction cost, inexpensive maintenance, years of favorable experience, availability of experienced contractors, and availability of good local materials. These surface treatments have a significant influence on pavement performance. Problems associated with surface treatments include flushing/bleeding in wearing courses, debonding at the interface with the base layer, poor ride, loss of aggregate (raveling) and ineffective sealing of the pavement. When surface treatments are used as underseals, failure of the underseal may lead to failure of the surface layer. Constructability issues related to surface treatments often dictate their performance. However, a formal statewide constructability review of surface treatments over base has not been conducted either by TxDOT or by other state highway agencies in the recent past. Recently concluded TxDOT research project 0-1787: Seal Coat Constructability Review, was well received by TxDOT personnel as well as the contracting community. It resulted in a number of operational changes in seal coating procedures including a specifications update. A similar study on surface treatments placed on prepared base could make the surface treatment construction operations more effective, resulting in longer lasting and higher quality pavements. This objective of this research project is to conduct a comprehensive constructability review of surface treatment as practiced by TxDOT districts, and to identify best practices.
Abstract
Deep Mixing (DM) technology is an in-situ mixing of stabilizers with soft and/or expansive soils to form deep columns. The treatment method uses stabilizers such as quicklime, cement, lime-cement and ashes to modify weak subgrades. The DM treated columns provide substantial improvements to soil properties by enhancing soil strength and compressibility properties. The DM columns have been used on several state highways to improve slope stability of earth structures, improve bearing capacities of soils, reduce heave and settlements of embankments and roadways, provide lateral support during excavations, and reduce bridge approach settlements. This technology has been used by various state DOT’s in the U.S. including Caltrans, Utah DOT, and Minnesota DOT in cooperation with the National Deep Mixing (NDM) Program, a research collaboration of the FHWA and ten State DOTs. A research report prepared by the NDM has mentioned the need to address potential DM applications in expansive soils such as those commonly found throughout Texas. The main objective of the proposed research is hence to address the effectiveness of this DM technology for stabilizing expansive and low bearing soils deeper than conventional construction methodology. In this study, researchers plan to design, construct and monitor two instrumented test sections on DM treated expansive soils and two instrumented control sections on untreated soils. Field treatments will be performed with a stabilizer that provided maximum enhancements to control soil properties in laboratory conditions. The effectiveness of the DM method will be measured in terms of better performance with less soil movements at significant cost savings. A successful DM methodology will not only reduce the roughness of pavements, but also enhances ride comfort. The main outcomes of this research will be the development of the most effective optimal column spacing, diameter and depth of DM columns that can be used to effectively stabilize expansive and soft soils located in Texas and the development of design and construction methodologies of DM columns for different expansive soil conditions. Also, a successful completion of this research will lead to potential implementation of the deep mixing (DM) methodology in an actual highway project situated in expansive soils in Fort Worth, Texas.

Research Products
- Construction Specifications for Preparation of DM Test Plots
- Guidelines for Design of DM Test Columns Soil Types
- Pertinent sections and details

Research Universities and FY 2006 Budget
University of Texas at Arlington - $81,187
University Of Texas At El Paso - $15,000

Total Project Budget
$286,433
Abstract
In recent years, the effects of highway traffic noise have become an increasing concern in the United States as well as in other countries. At the same time, acoustical technology advancements have allowed agencies to lessen the adverse impacts of highway traffic noise, such as the development of one of the most common mitigation strategies: the use of traffic noise barriers. However, roadside traffic noise barriers only reduce noise to receivers that are close to the barrier, and they may not be feasible or reasonable to construct in certain situations. Noise barriers are expensive to construct and may not be an aesthetically pleasing alternative.

This project focuses on reducing the chief source of the noise, the tire-pavement interaction. There are clear advantages from reducing the noise at the source instead of placing a barrier between the source and the receiver. First, all receivers including drivers of vehicles can benefit. Second, the benefit can be achieved in situations where barriers are not feasible or reasonable to construct or when barriers may be objectionable for aesthetic reasons. If pavements can be designed to be quiet and are able to retain those quiet characteristics over their service life with reasonable maintenance, then the use of quiet pavements may earn approval by the FHWA as a noise mitigating measure. Moreover, if this design is achieved, the quiet pavement is likely to be a less expensive alternative to constructing sound barrier walls in neighborhoods. Research has shown that the surface characteristics of a pavement have a key influence on the generation of noise. This project will test the candidate quiet pavements and quantify the potential noise reductions over time, which may result in substantial cost reductions and improved community acceptance of highway projects.

Research Products
- Comprehensive plan for Phase II work
- Input data for TNM program supporting pavement noise reduction
- All noise data and models, showing noise change in pavements over time
- Noise measurement protocols for field and lab applications, data analysis, test procedures including trailer, roadside, and impedance tube.
- Upgraded noise trailer including manual of operation and calibration.
- Training materials
- Input data for TNM program supporting pavements noise reduction
- All noise data and models, showing noise change in pavements over time
- Noise measurements protocols for field and lab applications

Program Coordinator
German Claros, RTI

Project Director
Gary Graham, CST

Project Advisors
Dale Rand, CST
James (Jim) Parrish, CST
Michael Shearer, ENV
Victor Winston, CST

Research Supervisor
Terrence Dossey, CTR

Research Universities and FY 2006 Budget
Center for Transportation Research - $75,000

Total Project Budget
$430,000
Abstract
The Texas Department of Transportation, TxDOT, is preparing Safety Bond Projects to be let no later than December 2005. As part of the program, qualified flexible pavement widening projects on current pavement widths less than 24’ with ADTs greater than 400 are being developed statewide. This Research Project would assist in the pavement design and construction details of these widenings as well as special notes tailored for this type of projects. In flexible pavement widening projects, including repair of existing flexible pavement sections, design often addresses a variety of construction materials, stabilization techniques and scheduling. Considerations for design and construction may include the following:

- Resulting non-homogeneous pavement section behavior
- Evaluation of maintenance of a resulting pavement section.
- Evaluation of soil conditions and their bearing capacity for pavements.
- Provide proper sub-surface pavement drainage.
- Evaluate limits of replacement (cut and add-on) verses re-work (scarify and re-shape) the whole cross section.
- Evaluate the joint performance, joint to wheel path relationships.
- Evaluate and recommend the best pavement surface alternatives.
- Recommend construction schedules, traffic control planning options, etc.

To address these considerations and others, this study would focus on guidelines for design, construction and scheduling of widening and repair sections to maximize value and life of the pavement section. This study should conclude 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 or repaired pavement. The draft guidelines for the design should be available after the first 6 months of this project so the districts could use these guidelines in the design of their projects.

Research Products
- Draft Guidelines for Design of Widening Projects
- Field Guide for Engineers
- Field Guidelines for Design of Widening Projects

Research Universities and FY 2006 Budget
Texas Transportation Institute - $60,000

Total Project Budget
$120,000
Abstract
The Texas Department of Transportation (TxDOT) in cooperation with the Federal Highway Administration (FHWA) has established a Pooled Fund Study. The objective of this study is to integrate the accelerated pavement test technologies of Texas, Louisiana and other participating State with modeling capabilities developed by the FHWA in their Truck Pavement Interaction program. This study will focus on the calibration and implementation of the latest version of the TPI software suite of vehicle-pavement-economic models to address Truck Size and Weight policy issues related to the economic impact of heavy loads along the NAFTA corridor.

The pavement damage predictions will be made using a calibrated version of the VESYS 5 Mechanistic/Predictive model, which have been under development by the FHWA for the past two decades. During the course of this project this software system calibrated with Accelerated Pavement Test (APT) data from Texas and participating states and the system will be implemented in a Windows based format for State use. The proposed research contract by the Texas Transportation Institute and the University of Texas at El-Paso will provide modeling, laboratory testing and automation support to this national pooled fund study.

Research Products
• Training sessions to TxDOT and others participating states
• Workshop and training to TxDOT and other participated states
• Enhanced VESYS 5 Window-Version Software
• VESYS 5 Software User Manual
• The Neural Network Software
• Manual for Neural Network Software
• The Software and associated manuals for Superheavy Load Movement in NY

Research Universities and FY 2006 Budget
Texas Transportation Institute - $50,000
University Of Texas At El Paso - $32,000

Total Project Budget
$554,000
RMC 2 - Overview
### RMC 2 – New Starts

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5217</td>
<td>Vehicle/License Plate Identification for Toll Collection Applications</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5286</td>
<td>The Role of Preferential Treatment for Carpoools in Managed Lane Facilities</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5322</td>
<td>Investigation of Rail Facilities Relocation in the U.S. and Potential Lessons for Texas Rail Planning Initiatives</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5339</td>
<td>Integration and Consolidation of Border Freight Transportation Data for Planning Applications and Characterization of NAFTA Truck Loads for Aiding in Transportation Infrastructure Management</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5345</td>
<td>Regional Public Transportation Solutions for Intercity Commute Traffic</td>
<td>8/31/07</td>
</tr>
<tr>
<td>0-5392</td>
<td>Impacts of Current and Future Demographic Trends on Transportation Planning in Texas</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5410</td>
<td>Developing Freight Highway Corridor Performance Measure Strategies in Texas</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5437</td>
<td>Impacts of Toll Roads on the Regional Economy</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5453</td>
<td>Strategies for Improving Travel Time Reliability</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5534</td>
<td>Asset Management - Texas Style</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5545</td>
<td>The Role of Private-for-Hire Vehicles in Texas Public Transit</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>

### RMC 2 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4080</td>
<td>Second Generation Activity-Based Travel Modeling Systems for Metropolitan Areas in Texas Accommodating Demographic, Land Use, and Traffic Microsimulation Components</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4871</td>
<td>Transportation and the Texas Economy</td>
<td>2/28/2006</td>
</tr>
</tbody>
</table>
## RMC 2 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5025</td>
<td>Promoting Local Participation on Transportation Improvement Projects</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5068</td>
<td>Planning for Container Growth Along the Houston Ship Channel and other Texas Seaports</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5157</td>
<td>Operational and Safety Impacts When Retrofitting Bicycle Lanes</td>
<td>11/20/2005</td>
</tr>
<tr>
<td>0-5176</td>
<td>Conversion of Volunteer-collected GPS Diary Data to Travel Time Performance Measures</td>
<td>12/31/2005</td>
</tr>
<tr>
<td>0-5178</td>
<td>Measuring Access to Public Transportation Services</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5531</td>
<td>An Assessment of a Traffic Monitoring System for a Major Traffic Generator to Improve Regional Planning</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5542</td>
<td>Integrating Regional Multimodal and Public Transportation Planning</td>
<td>12/31/2006</td>
</tr>
</tbody>
</table>
RMC 2 - New Starts
Abstract

Electronic toll collection (ETC), specifically open road tolling (ORT), is quickly becoming preferred practice among toll authorities in the U.S. and internationally. ORT technology has proven to be the most successful segment of Intelligent Transportation Systems (ITS) deployment. ORT therefore provides the opportunity for DOTs to introduce additional features of ITS, including roadside-to-vehicle communication and vehicle credentialing. Vehicle identification and registration via smart stickers or electronic license plates would provide significant benefits for toll collection as well as transportation system management. This research project will evaluate current and promising technologies for integration of toll collection with vehicle registration, analyze standards, legislation, organizational strategies and public acceptance, and develop an outline business model for implementation.
Abstract
High-occupancy vehicle (HOV) facilities are an important element of the transportation systems in Houston and Dallas, and are being considered in other metropolitan areas in the state. The Texas Department of Transportation (TxDOT) and partnering agencies have learned a great deal about the design, operation, and enforcement of HOV lanes over the past three decades. With the evolution of HOV facilities to managed lanes, and the increasing level of activity in the development of managed lanes in Texas and nationally, there is a need for research and guidance defining the role of carpools in priced managed lanes and the tradeoffs between carpool exemptions and other project objectives. Increasingly, project objectives are reflecting not only mobility concerns but funding deficiencies and the need to generate revenue. As a result, allowing exempt users such as carpools requires an evaluation of revenue impacts as well as mobility interests such as person movement, operations, and emissions.

This research will help identify the benefits, drawbacks and tradeoffs of providing preferential treatment for carpools and vanpools in managed lane facilities. The research will involve a review of the state-of-the-practice in carpool preferences on managed and tolled lanes, a stated-preference survey of HOV lane users with respect to carpool preferences relative to price, development of a predictive demand model, and an assessment of mobility, revenue, and environmental impacts. The findings and products of this research will be of immediate use and benefit to TxDOT and partnering agencies. Early research findings will be reported throughout the two-year project to help ensure the timely application of key research results.
Abstract

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, as well as roadway traffic, can be adversely affected. One approach to addressing this problem is to consider the relocation of through-train operations to new rail corridors located outside urban boundaries. It is theorized that by removing through-train operations from congested urban areas, select rail relocation projects could potentially improve the efficiency of the rail transportation system to the point that incremental but essential growth in truck-to-rail modal diversion could result. This project examines rail relocation projects in the United States to determine best practices, document cost-benefit analysis factors, 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 including project costs, impacts upon urban and outlying communities, potential funding mechanisms, and how potential rail relocation projects can be integrated with planning for the Trans Texas Corridor (TTC).
Abstract
Increasing numbers of Texans are commuting from outlying communities to jobs in urban areas and suburban areas. The current separation of urban and rural public transportation services means that Texans who travel between jurisdictions - from rural or suburban communities into cities or the reverse - often find public transit a difficult or unviable mode of transportation. As increasing numbers of Texans commute to urban-area jobs from rural or suburban communities, or travel across transit jurisdictions for medical care, this barrier to public transportation use is likely to contribute to a declining ridership share for transit in many significant travel corridors. To truly serve the future transportation market, transit service will need to become less stratified and more regional, with seamless connections for passengers between one provider and the next. This research will examine commuter travel to Texas’ urban centers from outlying cities, suburbs and rural communities and propose methods and strategies to improve coordination and travel opportunities for these markets.

Program Coordinator
Karen Dunlap, PTN

Project Director
Paul Moon, PTN

Project Advisors
Joe Holland, AUS
Fred Rojas, PTN
Gary Williams, PTN

Research Supervisor
Carol A. Lewis, TSU

Research Products
- Transit Coordination Guideline
- Brochure

Research Universities and FY 2006 Budget
Texas State University – San Marcos - $48,310
Texas Southern University - $28,750
Prairie View A&M University - $26,690
Texas Transportation Institute - $21,250

Total Project Budget
$193,203
Abstract

The quantity of truck transportation handled in Texas increased dramatically in the 1990s especially after the full implementation of the North American Free Trade Agreement (NAFTA). Accurate information on truck volumes and truck characteristics is critical to the transportation planning and transportation operation activities performed by TxDOT and other agencies responsible for the freeway and roadway system in the State of Texas. Information for freight transportation planning, in particular truck-related data is expensive and difficult to collect, but various agencies located at the Texas-Mexico border already gather information that is used for operation or statistical purposes. This project will identify planning information needs, determine data that is being collected by various federal, state, and local agencies, and propose an integrated truck-related information system that could be used for planning purposes. The project will also collect and analyze loading characteristics of heavy vehicles associated with cross border trade required for determining infrastructure impacts.

Research Products

- Truck information integration system structure that accurately captures information collected by the various agencies at the Texas-Mexico border
- Database with load characteristics of Mexican-domiciled trucks that may affect the surface transportation infrastructure
Abstract
Demographic data play an integral part in TxDOT planning processes and demographic processes and trends will markedly impact future demands for transportation and the characteristics of those using transportation services. The project will: produce a comprehensive evaluation of the current state of demographic data use in TxDOT; develop, test and involve TxDOT district and State-level personnel in an evaluation of, a CD/DVD data base with data items appropriate for use in county and district level planning that have been suggested by the data evaluation and by participants from a stateside survey of TxDOT district and state-level personnel; and assess the implications of future demographic trends for key policy areas likely to impact future TxDOT planning and operational activities. A user-tested data base (with appropriate documentation) as well as a comprehensive report on the state of demographic data in TxDOT and on the implications of current and future demographic trends will be produced as products from the analysis. Included in the final report will be recommendations regarding other demographic data and analysis that may be essential to TxDOT future planning and other assessments.
Abstract
Growth in global and regional trade is placing increasing demands on modal networks transporting the various commodities from origins to destinations.

Users are now placing increasing reliance on performance measures to monitor the efficiency of the modes and then make appropriate decisions about the choice of supply chain configurations. On the highway side (the focus of this scoping study) many users, through a variety of technologies including GPS, are now tracking their vehicles and are able to discern performance patterns. The state agencies responsible for constructing, maintaining and rehabilitating highway networks, however, have little performance data to use in decision-making, apart from those urban networks managed using ITS technologies. As a consequence, the Federal Highway Administration (FHWA) began in 2002 to explore the potential for collecting freight performance data from the national highway corridor networks and how that data could be used effectively by state agencies like TxDOT. This one-year scoping study will consider a range of performance measures being considered for both urban and inter-city corridors, examine the FHWA freight performance study now entering phase two, and recommend performance measure strategies that could be implemented at both TxDOT district and division levels to improve planning. Intensive traffic generators like retail "big box" distribution centers are also contributing to corridor performance and will be examined in the study. FHWA staff working on the second phase of their performance measure study have agreed to be part of the study and this will expedite initial progress on this study.

Research Products
- Workshop and Associated Materials
- Indices for Rural and Metropolitan FPM
- FPM Corridor Guide

Research Universities and FY 2006 Budget
Center for Transportation Research - $78,261
Texas Transportation Institute - $61,600

Total Project Budget
$139,861
The Texas Department of Transportation (TxDOT), regional toll authorities, and regional mobility authorities (RMAs) are planning, constructing, and operating numerous toll projects to meet growing mobility needs throughout the state. As toll projects are considered, questions often arise concerning the impact of these facilities on the local and regional economy. Although toll facilities have been in operation in Houston and Dallas for many years, the economic impacts of these toll projects have not been well documented. This research project will provide TxDOT and other interested groups with information on the potential economic impacts of toll facilities, techniques to assess the likely economic impacts, and possible approaches to maximize the economic development benefits of toll projects. The research results, which will include a brochure and presentation, a guidebook and a workshop, will be of immediate use to TxDOT personnel, as well as toll authority and RMA staff.

**Research Products**
- PowerPoint Presentation 10-15 minute on economic impacts of toll projects
- Popular brochure (final) - concise summary of similar material as PowerPoint presentation
- Guidebook - methods for identifying and estimating economic impacts and maximize economic benefits
- Workshop and Training Materials. Workshop will explain contents of the guidebook including step-by-step process to assess economic impacts of toll projects. Training Materials will include an instructor’s guide, PowerPoint presentation, and handbook

**Abstract**

**Program Coordinator**
Robert Stuard, AUS

**Project Director**
Jim Heacock, HOU

**Project Advisors**
Edward (Ed) Goebel, LBB
Jana Doyle, TTA
Jennifer Moczygemba, SAT
Lanny Wadle, FIN
Martha Boyd, ELP
Matt Macgregor, DAL
Ron Hagquist, TPP

**Research Supervisor**
Linda Cherrington, TTI

**Research Universities and FY 2006 Budget**
Texas Transportation Institute - $108,813
University Of North Texas - $49,967

**Total Project Budget**
$158,780
Abstract

In this research project an effective and theoretically sound framework and approach to evaluate the travel time reliability associated with highway projects is presented. The evaluation of travel time reliability focuses on the interplay between driver’s adaptation process (in response to travel time reliability) and the actual traffic variability resulting from the joint effects of driver’s route and departure time choice as well as from the random events that disturb the network capacity. In addition to the theoretical investigation of both trip maker’s route choice, departure time choices, and the equilibrium analysis, the research team also proposes a user-friendly computerized tool that can be used by TxDOT engineers or MPO planners to capture and quantify the network travel time reliability under different project specifications. The tool is aimed at integrating with existing model and process (e.g. TransCAD) in order to improve the compatibility of the developed model with the existing process. A toolbox consisting of strategies for improving travel time reliability will also be developed.

Research Products

- Toolbox of strategies for improving "travel time reliability" including input into how to communicate and implement certain strategies.
- Project Evaluation Tool to evaluate the travel time reliability improvement of various projects.
- User’s guide for the project evaluation tool.
- Interim documentation of the first -year study

Research Universities and FY 2006 Budget

University Of Texas At El Paso - $93,342

Total Project Budget

$189,107
Abstract
The objective of this project is to develop an Asset Management approach and implementation work plan in cooperation with, and for, the Texas Department of Transportation (TxDOT). The Asset Management approach will be aligned with TxDOT goals and policies to provide the necessary framework for the development and implementation of an Asset Management Decision Support System oriented to improve the methods and tools currently used by the agency to efficiently allocate resources. The scope of the project includes reviewing current information management and decision support systems inside and outside of TxDOT, conducting organizational analysis interviews with key administrators and managers within TxDOT, conducting Asset Management Workshops, developing approaches to formalizing an Asset Management Decision Support System within TxDOT, proposing performance measure strategies, preparing an Asset Management Guidebook, and development of an implementation work plan that includes marketing strategies. The benefits of developing and implementing a TxDOT Asset Management framework for improving asset management practices will be reflected in lower long-term costs and improved performance of the transportation facilities managed by TxDOT.

Research Products
- Asset Management Guidebook Outline
- Preliminary PowerPoint Presentation on Asset Management in TxDOT
- Final Version of Asset Management Guidebook
- Implementation Plan for TxDOT Asset Management
- PowerPoint Presentation on Asset Management in TxDOT
- Draft Information Brochure. Executive Summary of Key Findings
- Information Brochure. Executive Summary of Key findings
Abstract
The Texas Department of Transportation (TxDOT) is embarking on a multi-decade effort to expand the state’s transportation system. This expansion includes the multiple, high-speed corridors of the Trans-Texas Corridor, as well as other facilities. TxDOT has expressed an interest in using very high design speeds (above 80 mph) for these facilities to promote faster and more efficient travel within the state. Currently, state and national roadway design guidance does not provide for design speeds above 80 mph, so roadway designers do not have any design values for facilities with very high speeds. In addition, very high speeds increase the energy of vehicles striking roadside objects. These objects, including safety devices such as barriers and crash cushions, have not been designed with these speeds in mind. If very high-speed facilities are constructed, there is a need to provide appropriately designed safety hardware. The purpose of this project is to expand upon existing design guidance and include new criteria for design speeds up to 100 mph. Also, the research needs for roadside safety devices will be explored.

Research Products
- Recommended updates to the Roadway Design Manual for design speeds up to 100 mph

Research Universities and FY 2006 Budget
Texas Transportation Institute - $149,981

Total Project Budget
$149,981
Abstract
The Texas State Transportation Code's new Chapter 461 focuses on maximizing the benefits of the State’s investment in public transportation through the coordination of services. In response, the Texas Transportation Commission, under the leadership of Commissioner Hope Andrade established the Regional Planning and Public Transportation Study Group. The Study Group recommended that each region of the state develop and submit a regional coordinated public transportation service plan to the Commission by September 2006. Private-for-hire vehicles (PHVs) are an important component of Texas’ public transportation mix. Recent national research indicates that PHVs are a cost-effective and possibly underused method of service delivery. This research project will build on the national study and will examine the PHV industry within Texas and the role of PHVs in a coordinated public transportation system. The project will develop guidelines for the procurement and administration of successful PHV-public transit partnerships. The research results will be of immediate use and benefit to TxDOT, the regional transportation planning groups, and public transportation agencies. Using websites, scheduled meetings, and other communication methods, the research products will be made available throughout the project to respond to the needs of TxDOT staff, the Study Group, and the regional planning groups.

Research Products
- An understanding of the benefits and limitations of private-for-hire vehicles augmenting public transportation in Texas.
- Techniques for engaging the PVH industry in transit coordination activities

Research Universities and FY 2006 Budget
Texas Southern University - $4,003
Texas Transportation Institute - $120,997

Total Project Budget
$125,000
RMC 2
Continuing Projects
Abstract
Reliable travel demand forecasts are critical prerequisites to good transportation policy analysis and transportation infrastructure investment and system operations decisions. The need for improved demand analysis procedures has also received a major impetus because of the requirements placed by the Clean Air Act Amendments (CAAs) and the Intermodal Surface Transportation Efficiency Act (ISTEA) on travel forecasting methods to enable reliable assessment of future mobile-source emission levels and to evaluate the effects of transportation control measures.

The commonly used "trip-based" approach to travel demand analysis, developed in the late 1960s, has a number of limitations, which can lead to unreliable analysis of travel demand management options, and unreliable forecasts of travel demand in response to changing urban form and or population socio-demographics. The discontent with the conventional disaggregate "trip-based" choice approach has led to the emergence of an activity-based travel approach to explain urban movement. The activity-based approach views travel as a derived demand; derived from the need to pursue activities distributed in space. The approach explicitly considers the all-important link between activity participation behavior and travel behavior, accommodates the interaction among different activities pursued by an individual, and accommodates the interaction between the temporal and spatial dimensions of activity participation.

The activity-based travel analysis approach is intended to be the basis for the next generation of travel demand models. Thus, it is important for the State of Texas to invest in a research program for the development of such a comprehensive activity-based travel modeling approach. The proposed project will develop a methodologically sound, yet application friendly, GIS-based modeling tool for activity-based travel analysis to aid Texas Metropolitan Planning Organizations (MPOs) in their transportation-air quality modeling efforts, and in the transition from trip-based to activity-based methods.

Research Products
- Revised version of P1
- Revised version of P2 to accompany P8
Abstract

In setting the state’s future spending priorities, Texans will be analyzing and evaluating the importance and dimensions of the state’s transportation system and network and their role in the Texas economy. Current, accurate, and objective economic measures that delineate the importance of transportation to Texas are crucial to the public debate and policy-making process in deciding what Texans want for their transportation system. In reporting the results, the proposed study will compile, using existing US and Texas based data sources, an economic profile of the importance of the transportation system and its services to the State of Texas, which may include:

1. All transportation outlays and the Gross Texas Product
2. Outlays for freight transportation, total and by mode
3. Outlays for passenger transportation, total and by mode
4. Employment in transportation and related industries
5. Outlays for transportation equipment and investment in capacity
6. Governmental expenditures for transportation services and facilities

These results will be presented in a research report and a handy, pocket guide.
Abstract

TxDOT’s statewide transportation program has been planned to meet projected transportation needs across the state. Unfortunately, available financial resources are not sufficient to fully fund the desired program. The 2003 legislature created additional tools and funding. However, even more is needed. One of the major untapped potential sources is local funding. TxDOT seeks to increase local funding participation in its projects as well as local support for TxDOT to implement tolling in non-traditional ways. TxDOT desires to attract local funding to its major projects by demonstrating economic benefits of major transportation projects to local areas. Since local agencies also find themselves with limited transportation funding, TxDOT wishes to demonstrate that additional sources exist or could be made available to increase local revenues. This project will develop lists and examples of economic and other benefits that result from major transportation projects, estimation methods to quantify the economic benefits, and existing and innovative funding sources for local entities. The project will develop a guidebook for TxDOT and others to apply the tools developed as well as a prototype prospectus of benefits for a sample project, and a presentation for use by TxDOT to educate local staff and decision makers.
Abstract
Containerized freight movement into Texas has been growing and is projected to double during the next 20 years. Because the ports on the Houston Ship Channel are likely to remain the center of shipping in and out of Texas, and because the Houston region and other parts of Texas continues to be plagued by traffic congestion, it would be of great benefit to TxDOT to consider innovative freight movement solutions that could be integrated into regional and statewide plans. This research project will bring together the major stakeholders of intermodal freight movements in the Houston region, as well as other areas along the Texas coast, develop forecasts of container growth, evaluate developments and proposals for moving freight, integrate plans for inland ports and hubs on the Trans Texas Corridor routes, analyze detailed strategies and costs for improvements along the Houston Ship Channel and other Texas ship channels, propose funding options, and produce an action plan for managing growth of container traffic around the port of Houston and other Texas ports.

Research Products
- Digital GIS maps of ports, rail network and roadway infrastructure along the Houston Ship Channel and other Texas seaports
- Inventory of rail infrastructure serving the three ports along the Houston Ship Channel and other Texas seaports
- Power point presentation summarizing the major study findings
Abstract

The most widely-used manual for bicycle infrastructure creation is the AASHTO Guide for the Development of Bicycle Facilities (3rd edition), which presents minimum standards for physical design. For bicycle lane width, however, the manual provides no guidance on practical solutions for the common scenario where expanding the street right-of-way is not feasible. The proposed research will fill this gap by undertaking field observations and then analyzing the data collected in combination with evidence from other sources. The field data will include safety and operational levels, plus the factors besides bicycle lane width that explain the variation in these levels. Such factors include: vertical and horizontal alignments, traffic volumes, speed limits, adjacent land uses, cross sections, driveway densities, drainage, pavement conditions, and medians. The researchers will produce a manual that allows the planner or designer to (1) select the best route among a set of physically constrained streets in a corridor, and (2) configure the optimal geometric solution for adding a bicycle lane to the chosen street. Data permitting, this project will also produce a computer software package version of the manual.

Program Coordinator
Maria Burke, DES

Project Director
Carol Nixon, HOU

Project Advisors
Charles Gaskin, HOU
Jenny Peterman, AUS
Ken Zigrang, SAT
Mark Farris, DAL
Paul Douglas, TPP
Paul Moon, PTN
Teri Kaplan, HOU

Research Supervisor
Randy Machemehl, CTR

Research Products

- Written guide to selecting among limited right-of-way streets and designing geometric solutions for the provision of bicycle lanes
- Excel workbook to calculate bicycle compatibility indexes and passing event model values for bicycle facility design and evaluation
- DVD copies of field test videos
- Digital Map of Test Sites
Abstract
Household travel survey data constitute a fundamental input to travel demand model development for use in transportation planning and policy analysis. Conventional travel survey methodologies require the collection of detailed address and travel information, which impose a significant burden on potential respondents, thereby adversely impacting the quality and quantity of data obtained. The Global Positioning System (GPS) technology, because of its passive and accurate data collection capabilities, has the potential to reduce the dependence on travel surveys. The data recorded by GPS devices, however, does not directly yield travel information; the navigational streams have to be processed and the travel patterns derived from it. This research proposes the development of a prototype software for automating the conversion of raw GPS data (obtained from in-vehicle GPS devices) into a traditional activity-travel diary data set. The software will identify trips, and characterize them by several attributes including trip-end locations, trip-purpose, time-of-day, distance, and speed. The results will be presented to the analyst in a tabular form and/or on a GIS map, as desired. Further, the software will also be capable of aggregating the derived trip diary data to produce trip tables (by purpose and time of day) and to compute highway performance measures such as inter-zonal travel times and speeds (by time of day).

Research Products
- Detailed processing methodology for extracting travel diary data from the GPS navigational streams associated algorithms
- The prototype GPS-TDS software for analysis and manipulation of GPS Data
- User Guidebook to discuss the use of, and the many options built into, the software platform
- A Complete Set of Sample Electronic files to demonstrate the work of the software for demonstration purposes
- Training Workshop on the use of the GPS-TDS Software Platform

Research Universities and FY 2006 Budget Center for Transportation Research - $30,000
Total Project Budget $150,000
Abstract
Accessible and effective services are vital features of a well-utilized public transit system. Also important is the equitable distribution of the services to all people, whether or not they own a car and regardless of age, ability, ethnicity, or income. These policy goals place transit service delivery in the context of accessibility. The objective of this project is to develop measures of accessibility that would address the spatial, temporal and other dimensions of transit demand and supply. Separate indices are proposed to measure four specific aspects of this demand and supply interaction: access to transit, trip origin-destination connectivity, temporal transit availability, and transit capacity. The indices will be population subgroup-specific and purpose-specific, so that differentiation can be made in the levels of service provided to different population subgroups and trip purposes. The four indices will further be consolidated into successively more aggregate indices and ultimately into a single generalized measure that represents the overall accessibility for a region. The measures will be implemented in an analysis tool that runs on a GIS platform. The tool can be used to identify areas in need of transit improvement by recognizing the special accessibility needs of various customer groups and matching services to both existing and emergent travel patterns.

Research Products
- Initial version of the TransCAD-based application software for transit accessibility
- TransCAD-based model for computing transit accessibility
- User guidebook to discuss the many options built into the TransCAD platform for analysis
- Electronic files for the data, outputs, and displays of outputs in TransCAD format
- Electronic ArcGIS files for the data, outputs, and displays of outputs supporting the analysis of the seven selected urban areas
- Training workshop in the use of the transit accessibility platform
- Documentation of all research performed, methodology used, and conclusions/recommendations
Abstract
Regional planning relies on many types of data, e.g., roadway network maps, capacities, demands, vehicle classification, vehicle occupancy, demographic data, origin/destination data, etc. A portion of these data can be available via automated data collection. When plans for a mega-traffic generator, e.g., an automobile manufacturing plant, are announced modifications to the regional plan become necessary. In addition, as in the case of the Toyota Motors Manufacturing Texas (TMMTX) plant in Bexar County, where a mega-traffic generator is located in an isolated area where traffic volumes are light, there is an opportunity to monitor changes in traffic characteristics and apply lessons learned to other future megatraffic generator sites. The specific case study at TMMTX includes an assessment of the types of regional planning data that can also be collected in an automated fashion, the development of the types of reports that can be generated from such data, criteria for data collection sites, data reporting scenarios, data collection and communication equipment architecture, and data collection and analysis.

Research Products
- Recommendations on equipment for multiple scenarios
- PowerPoint presentation #1 of research findings prior to opening of the Toyota Plant
- Guidebook for prototype traffic monitoring plan
- PowerPoint presentation #2 covering entire research effort
- Workshop and Training Materials
- Data Collection Equipment including accessories

Research Universities and FY 2006 Budget
Texas Transportation Institute - $82,000
University Of Texas At San Antonio - $18,000

Total Project Budget
$268,340
Abstract
Chapter 461 of the Texas State Transportation Code focuses on maximizing the benefits of the State’s investment in public transportation through the coordination of services. Accordingly, the Texas Transportation Commission, under the leadership of Commissioner Hope Andrade, established the Regional Planning and Public Transportation Study Group. The mission of the Study Group is to review current public transportation planning and programming practices within metropolitan, suburban, and rural areas and to enhance service delivery, customer satisfaction, efficiency and effectiveness. The Study Group recommended that each region of the state develop and submit a regional coordinated public transportation service plan to the Commission by September 2006. The objective of this research project is to support the Study Group and assist each region to develop a regional transportation plan. The focus of research will be to review and assess the state of the practice in coordinated public transportation, to identify and share best practices, and to develop an internet based clearinghouse of technical information on relevant public transportation planning processes and strategies. The research results will be of immediate use and benefit to TxDOT, the Study Group, the regional transportation planning groups, and public transportation agencies to develop and submit regional coordinated transportation service plans by September 2006.

Research Products
- Website: Regional Public Transportation Planning Clearinghouse

Research Universities and FY 2006 Budget
Texas Transportation Institute - $108,000
West Texas A&M University - $17,000

Total Project Budget
$160,000

Program Coordinator
Karen Dunlap, PTN

Project Director
Shawna Russell, ADM

Project Advisors
Jim Reed, MPO
Lara Rodriguez, NCTCOG
Mary Hobson, FTW
Michael Morris, NCTCOG
Norman Schenck, COT

Research Supervisor
John Overman, TTI
RMC 3 - Overview
### RMC 3 – New Starts

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5226</td>
<td>Evaluation of Texas Native Grasses for TxDOT Right of Ways</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5290</td>
<td>Left-Turn Lane Design and Operation</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5330</td>
<td>Synthesis of New Methods and Techniques for Developing Sustainable Roadside Landscapes</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5475</td>
<td>Collection, Integration and Analysis of Utility Data in the Transportation Project Development Process</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5478</td>
<td>Optimizing the Identification of Right-of-Way Requirements during the Project Development Process</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5492</td>
<td>Hydraulic Performance of Bridge Rails and Traffic Barriers</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5516</td>
<td>Synthesis of Wave Load Design Methods for Coastal Bridges</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5526</td>
<td>Impact Performance Assessment of Roadside Safety Appurtenances</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5527</td>
<td>Development of Transition Element for Low-Profile Traffic Barrier to Standard Concrete Traffic Barrier</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>

### RMC 3 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4193</td>
<td>Regional Characteristics of Unit Hydrographs</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4378</td>
<td>Establish Guidance for Soils Properties-Based Prediction of Meander Migration Rate</td>
<td>4/30/2006</td>
</tr>
<tr>
<td>0-4570</td>
<td>The South Texas Native Plant Restoration Project</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>
### RMC 3 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4605</td>
<td>Stormwater Quality Documentation of Roadside Shoulders Borrow Ditches</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4611</td>
<td>Non-Proprietary, Small Footprint Stormwater Quality Structures for Use in Urban Areas</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4695</td>
<td>Guidance for Design in Areas of Extreme Bed-Load Mobility</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4703</td>
<td>Incorporating Safety into the Highway Design Process</td>
<td>8/31/2009</td>
</tr>
<tr>
<td>0-4875</td>
<td>Minimum Longitudinal Grade at Zero Cross Slope in Superelevation Transition</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4949</td>
<td>Successional Establishment, Mowing Response and Erosion Control Characteristics of Roadside Vegetation</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4997</td>
<td>Effectiveness of Combined Utility Relocation/Highway Construction Projects</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4998</td>
<td>Standardization of Special Provisions and Determination of Unit Costs for Utility Installations</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5191</td>
<td>Investigation of Control Strategies for 8-Hour Ozone Standard</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5212</td>
<td>Comparison of Alternative Seed Mixes to Standard TxDOT Specifications</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5532</td>
<td>Galveston Ferry Operation (GFO) Engine TxLED Failure Assessment, Solution and Implementation</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>
RMC 3 - New Starts
Abstract
Researchers at Texas A&M University-Kingsville in conjunction with the Kika de la Garza Plant Materials Center will evaluate hooded windmillgrass and shortspike windmillgrass to quantify the time and effectiveness of these native grasses to germinate, establish and provide 70% land coverage on TxDOT right-of-ways under various soil textures (ie.. sandy loams, clay, . . .). This study will also quantify and document the performance of these grasses under mowing regimes typical on TxDOT right-of-way. This evaluation should provide the data necessary for replacing introduced plant species with native grasses in TxDOT specifications. It also should provide the necessary information for the seed commercialization of these two species and the subsequent release to the general public.

Research Products
• Report of germination, propagation, harvesting and commercial production of short spiked and hooded windmill grass

Program Coordinator
Barrie Cogburn, DES

Project Director
Dennis Markwardt, MNT

Project Advisors
Chano Falcon, PHR
Karen Clary, ENV
Robert Watts, ODA
Steve Orchard, CRP

Research Supervisor
Timothy Fulbright, TXAMK

Research Universities and FY 2006 Budget
Texas A&M University At Kingsville - $48,666

Total Project Budget
$150,422
Abstract
During the project development process, districts produce enormous amounts of engineering data in a variety of data formats with varying levels of accuracy and resolution on several types of storage media. Although district personnel have a wealth of data at their disposal, frequent lack of data integrity, accessibility, and quality control makes it unnecessarily difficult to put the data to good use. These inefficiencies result in redundant data collection efforts and contribute to project delays. This research project evaluates and documents current engineering design data management practices at TxDOT and develops prototype engineering data management processes to assist divisions and districts in their effort to manage engineering data effectively. To make the research tractable, the focus is on data types, spatial and temporal data flow control, and associated documentation used during the design phase of typical highway improvement projects. The research develops and tests prototype GIS-based engineering data management processes and accompanying metadata, develops and tests these processes for integration into the new TxDOT GIS architecture, and provides guidelines for implementation.

Research Products
• Prototype Engineering Data Management Processes and Procedures
• Prototype Engineering Process Integration with the GAIP GIS Architecture
• Recommended Modifications to Engineering Processes

Program Coordinator
Randy Hopmann, LBB

Project Director
Wesley Burford, AUS

Project Advisors
Byron Miller, ISD
Jennifer Moczygemba, SAT
Linda Olson, DES
Matt Carr, ODA
Neil Welch, LBB
Phil Hancock, ISD
Jason Dupree, ATL

Research Supervisor
Cesar Quiroga, TTI

Research Universities and FY 2006 Budget
Texas Transportation Institute - $125,050

Total Project Budget
$243,690
Abstract
A left-turn lane is used at an intersection to improve the safety and/or operations of the intersection by providing space for the deceleration and storage of turning vehicles. It reduces the shock wave effect caused by a speed differential. This project is intended to examine important issues related to the design and operation of left-turn lanes and recommend best practices that could improve both safety and efficiency of intersections. To this end, the research will (1) synthesize national practices from other states on the design and operation of left-turn lanes, (2) identify important parameters/variables that are associated with the determination of deceleration and queue storage length requirements for left-turn lanes, (3) develop procedures and methodologies for determining queue storage lengths for both signalized and unsignalized intersections, (4) determine criteria for determining when to install multiple left-turn lanes, (5) examine safety benefit resulted from the increased queue storage length, and (6) examine other relevant elements associated with the design and operation of left-turn lanes, such as traffic controls, taper rate, pavement markings (e.g., use of dashed lines), etc.

Program Coordinator
Meg Moore, TRF

Project Director
Cynthia Landez, DES

Project Advisors
Cynthia Flores, TRF
Gerardo Vallejo, PHR
Ray Thomasian, DES
Tyrone Hamilton, HOU

Research Supervisor
Lei Yu, TSU

Research Products
- Methodology for left-turn storage calculations

Research Universities and FY 2006 Budget
Texas Southern University - $140,000

Total Project Budget
$290,000
Abstract
In order to maintain federal regulatory compliance and ensure that the most effective erosion control products are used on their construction and maintenance projects, TxDOT bases material selection on an approved product list (APL). This APL is based on field performance of the products through a formal evaluation program at the Texas Transportation Institute (TTI) Hydraulics, Sedimentation, and Erosion Control Laboratory (HSECL) at the Texas A&M University Riverside Campus. The two critical performance factors identified are:

- How well the product protected the seedbed of an embankment and drainage channel from the loss of sediment during simulated rainfall or channel flow events, and
- How well the product promoted the establishment of warm-season, perennial vegetation.

While these two factors are critical to erosion control performance, there has been no consideration for material cost and longevity. Furthermore, there are potentially less expensive erosion control techniques, which have not previously been included in the approval process. These techniques include crimped or tacked haystraw, compost, slope tracking, wood mulch, and soil binders. This study will synthesize all available performance and cost data of these nonmanufactured techniques in terms of cost, sediment loss prevention and vegetation establishment. This study will also look at the cost of current products on the APL in terms of costs for the material, installation, maintenance, repair, and effectiveness, to develop a cost-performance index. The objective of the effort is to produce an application guide for selecting the most cost effective erosion control materials and methods.

Research Products
- Selection and Application Guidance - recommended changes for the APL and specifications written for frontline design engineers

Research Universities and FY 2006 Budget
Texas Transportation Institute - $70,560

Total Project Budget
$70,560
Abstract

Federal and state agencies cite language contained within an executive "Memorandum on Environmentally Beneficial Landscaping" when reviewing and commenting on TxDOT's planning, design and construction documents. Environmentally beneficial landscaping entails utilizing techniques that complement and enhance the local environment and seek to minimize the adverse effects of development. In particular, this means using regionally native plants and employing landscaping practices and technologies that conserve water and prevent pollution. More specifically the directive states that agencies shall, "seek to prevent pollution by, among other things, reducing fertilizer and pesticide use, using integrated pest management techniques, recycling green waste and minimizing runoff." Several districts have developed innovative landscape efforts specifically seeking to establish sustainable landscapes that require little if any supplemental water and utilize no chemical fertilizers. The concept behind this approach is that as land use intensifies, surface water runoff increases and soils ability to absorb runoff diminishes. This is a common situation in the urban environment, and highlights the need for creative alternatives that can help reduce water runoff and increase groundwater infiltration. This is accomplished by utilizing the environmental processes that are the foundation for self-sustaining and self-sufficient plant communities found flourishing on their own outside the right-of-way. It has been clearly demonstrated that minimizing development impact on native soils and forests, and restoring impacted soils, can reduce peak storm flows and increase infiltration. Field experience and research strongly suggest that a natural approach to establishing self-sustaining plant communities within the urban roadway environment is both feasible and desirable. The further development and application of this approach requires a more comprehensive understanding of:

- the restoration of disturbed soils through suitable and cost-effective soil amendments,
- the use of IPM techniques (promote the least toxic approach to eliminating noxious weeds, and
- practices for initial establishment and management of plant materials.

This study seeks to analyze the current practice of plant community establishment and to identify the issues resulting in successful and less than successful projects. The study should conduct a thorough investigation into the current technologies, processes, and products that may be suitable for use in establishing improved vegetation through soil restoration. The study should include reports by other DOTS, commercial developments or other practices suited for the development of large-scaled projects. The study should identify those practices, products, and procedures that will be most likely to result in successful developments. Because of the climatic and vegetation diversity of Texas, the study should identify potential suitability of this approach within the context of urban roadways within all TxDOT districts.
Abstract
Right-of-way acquisition is a crucial component of the overall planning and implementation of highway and transportation projects. Over the last few decades, the right-of-way acquisition process has become significantly more complex, expensive, time consuming, and socially sensitive. The valuation of the parcels to be acquired and the negotiations with property owners are extremely important aspects of this process. Successful valuation can benefit TxDOT by reflecting fair market prices and building good rapport with landowners, which can also have an effect on the reduction of project duration.

Negotiation also has its own significant role in the acquisition process, not only by helping to maintain good relationships between TxDOT and property owners but also by increasing trust in transportation planning. Public satisfaction should be pursued, while maintaining the desired time and cost project performances. In order to achieve these goals many different types of issues need to be considered, such as practice differences among TxDOT districts, communication of engineering details in the early stages of new projects, differences in appraisal types and methodologies, and the effect of pertinent laws and statutes, among others. All these factors influence effective right-of-way acquisitions. Therefore, there is a need to summarize best practices in right-of-way valuation and negotiation. This research project aims to identify these best practices, as well as process differences, legal aspects, and influence factors related to ROW valuations and negotiations. A synthesis of best practices and a guidebook for ROW valuations and negotiations will be developed. These documents will be used as a guideline for ROW agents and outside appraisers on how to conduct effective ROW valuations and negotiations. Recommendations for implementation are also part of the scope.
Abstract
A critical process for the timely development and delivery of highway construction projects is the early identification and depiction of utility interests that may interfere with proposed highway facilities. The effective management of such utility interests or conflicts involves utility relocation (or design changes), inspection and documentation. The large number of stakeholders and the magnitude of the process results in an enormous amount of data in the form of communications, agreements, contracts, permits, maps, schematics, images, design files and other documents. Despite substantial data exchange between stakeholders, there are currently no standards for the exchange of utility data/information in the project development process. The proposed research will address this issue by analyzing specific information flows and data needs to determine data models and by developing a prototype utility conflict data management system. More specifically, the research will perform a comprehensive analysis of utility conflict data/information flows between utility accommodation stakeholders in the TxDOT project development process, develop data models to accommodate work and data flows between such stakeholders, develop a prototype system for the management of utility conflict data, and develop a tool for the visualization and analysis of utility conflicts within the prototype utility conflict data management system.
Abstract
Determination of right-of-way requirements during the project development process depends on many factors including proposed alignment, typical sections, access control, and accommodation for construction, drainage, clear zone, highway access maintenance, accessible pedestrian design, and environmental mitigation. In most cases, right of way survey and acquisition cannot begin until a design schematic has been completed and approved as well as receiving an approved environmental document giving authority for TxDOT to release the project for survey and acquisition of the right of way. However, a sufficient level of preliminary work must be accomplished by the design team to make an adequate right of way needs determination. The purpose of this research project is to review design-related factors in relation to the project development timeline to ascertain the impact of these factors on the determination right of way requirements. The product of the research effort will be development of a Best Practices Model, methodology or series of scenario-specific strategies to accelerate/optimize the right-of-way requirements identification process. The research will include a sensitivity analysis that allows early quantification of the level of certainty associated with right of way requirements. This tool would provide engineers and planners the means by which to run scenario specific analysis of right-of-way requirements in a more timely manner and with greater accuracy.

Research Products
• Right-of-Way Requirements Tool
• Best Practices Model

Research Universities and FY 2006 Budget
Center for Transportation Research - $102,508

Total Project Budget
$208,510
Abstract
TxDOT policy is to use crash-tested bridge rails on all new construction and for existing bridges scheduled for safety rehabilitation. Safety upgrade of bridge railing systems may result in rails with greater height and less open space. This design may result in poor hydraulic performance that may increase the water surface elevation for the 100-year return period flood event and raise significant issues with FEMA compliance that could result in delay and complication of projects. The objective of this research project is evaluation of the hydraulic performance of different bridge rail designs that have been crash-tested and found acceptable for TxDOT use.

A program of physical modeling experiments is proposed. Rating curves will be measured for each rail system that is tested. The rating curves provide models for predicting water surface elevation as a function of discharge (rate of water flow). The effects of rail submergence also will be evaluated. An additional series of experiments using physical modeling will evaluate the interaction of bridge rail, traffic barrier, and bridge decking in estimating the backwater caused by water flow over the bridge superstructure. Mathematical tools for prediction of hydraulic performance of bridge-rail systems will be developed. Recommendations on hydraulic analysis of bridge structures, including rails and barriers, will be developed, including possible modifications to models such as HEC-RAS for predicting water surface elevations.

Research Products
- Design guidelines and rating curves for hydraulic performance of bridge rails and traffic barriers
Abstract

Current bridge design codes appear to provide no guidance for the design of bridge superstructures subjected to storm wave and surge forces. These design codes appear to provide limited guidance for the design of bridge substructures as well as revetments. Historical records of extreme winds, storm surge, and wave height are scattered and in formats that are not user friendly in most cases. This research will focus on conducting a literature review to find the state-of-the-art and the state-of-the-practice of the design of bridge superstructures, substructures, and revetments when subjected to storm surge forces. Then, a description of the available methods for the design of the different elements of a bridge subjected to storm and surge forces will be made. The description of bridge design methods will include an identification of the design parameters necessary for the design of bridges subjected to storm and surge forces. The following phase of the project will identify and describe computer programs and available methods to estimate the bridge wave load design parameters. This task will be followed by a compilation and organization of these bridge design parameters from historical data. An updating process for the database will also be included as part of this research. In the event that no design methods for bridge elements subjected to storm surge forces are found, a plan of action for the development of a new method will be presented. A quantification of safety and financial benefits resulting from carrying out this research beyond the synthesis stage will be given. A final report will be written to describe the entire research process, findings, and conclusions.
Abstract
Guidelines for testing and evaluating the impact performance of roadside safety features are periodically updated to stay current with improvements in technology and changes in the vehicle fleet and impact conditions. NCHRP Report 350, which contains current recommendations for testing and evaluating roadside safety devices, was published in 1993. Research is currently being conducted under NCHRP Project 22-14(2) to update Report 350. This research effort is scheduled to be completed in 2005. Changes being proposed for incorporation into the new guidelines include new design test vehicles, revised test matrices, and revised impact conditions. These changes will likely necessitate the re-evaluation of the impact performance of some existing roadside features. The purpose of this research project is to assist TxDOT in developing a prioritization scheme for testing and evaluation of roadside safety features in accordance with the new impact performance guidelines. Categories of roadside appurtenances that will be investigated include but are not necessarily limited to longitudinal barriers (e.g., guard fence, median barriers, bridge rails), crash cushions and attenuators, breakaway supports (e.g., mailboxes, sign supports, luminaire poles), work zone or temporary barriers, and work zone traffic control devices. Existing crash test results, engineering analyses, computer simulation, and crash data analysis may be used to assist with the hardware evaluation and prioritization.

Research Products
- List of TxDOT- Utilized roadside safety hardware requiring testing and evaluation in accordance with new impact performance criteria

Research Universities and FY 2006 Budget
Texas Transportation Institute - $123,025

Total Project Budget
$123,025
Abstract
A low-profile barrier system was developed more than a decade ago for use in low-speed urban work zones where it is required to have frequent cross-traffic entrances. The height of the low-profile barrier was set at 508-mm (20-in.) instead of the standard 813-mm (32-in.) that is used for traditional work zone barriers. The reduced height of the low-profile barrier greatly enhances the ability of drivers who are traversing the work zone to maintain visual contact with the local traffic situation. Since its introduction, the low-profile barrier has demonstrated that it is extremely useful in increasing safety in such situations. The low-profile barrier system was developed for urban areas with uniformly low speed limits. However, there are a large number of situations where speed limits transition from low speeds to high speeds or vice versa. In such situations it would be very beneficial to derive the increased visibility benefits of the low-profile barrier in the low speed areas. However, the low-profile barrier cannot now be used in such situations because there is currently no approved hardware that can be used to connect the low-profile barrier to the taller traditional barriers. The objective of this research is to develop and test a transition barrier segment that can be used to attach the low-profile barrier to traditional portable barriers so that the improved visibility benefits can be achieved in the low speed zones and full protection can be provided in areas of higher speed. It is anticipated that the transition barrier segment can be utilized in both permanent and temporary applications.

Research Products
• Development of a transition rail element to connect low-profile traffic barrier (LPCB(1)-92) to standard height concrete barrier rail (CBR(P&P)-87). A standard sheet suitable for approval by TxDOT will be provided.

Research Universities and FY 2006 Budget
Texas Transportation Institute - $149,155

Total Project Budget
$149,155
RMC 3
Continuing Projects
Abstract

Improve hydraulic design practices by developing a deterministic basis for obtaining peak discharge and shape for hydrographs in hydraulic design regions of uncertainty (>200 acres and <10 square miles). Use rational method for <200 acres and use regression equations for >10 square miles.

Program Coordinator
Amy Ronnfeldt, DES

Project Director
George Herrmann, SJT

Project Advisors
Research Supervisor
David Thompson, TECHMRT

Research Universities and FY 2006 Budget
Center for Multidisciplinary Research in Transportation - $44,996
Lamar University - $25,000
United States Geological Survey - $50,000
University Of Houston - $25,004

Total Project Budget
$1,039,007

Research Products
- Guidance for development and application of synthetic unitgraphs for design applications
- Guidance for Application of Loss-Rate Functions
Abstract
Previous TxDOT research has shown several solutions for predicting the movement of meanders to be unreliable. The solution being developed in this project is novel in that it considers the soil erodibility as an independent parameter influencing the meander migration. Conventional parameters-flow velocity, meander radius of curvature, river width, and others-are of course also considered. Through a combination of full-scale case histories, well-instrumented small-scale flume tests, quality numerical simulations, and fundamental laboratory erosion tests, a simple and reliable solution will be developed and verified. The anticipated product is prediction procedure guidance for meander migration including site-specific soil properties.

Research Products
- Prediction procedure guidance for meander migration including site specific soil properties
- MEANDER: Computer program. Software to automate the prediction process.

Program Coordinator
Amy Ronnfeldt, DES

Project Director
Thomas Dahl, BWD

Project Advisors
David Wilson, USACE
George Herrmann, SJT
Mark McClelland, BRG
Peter Chang, FHWA

Research Supervisor
Jean-Louis Briaud, TTI

Research Universities and FY 2006 Budget
Texas Transportation Institute - $30,000

Total Project Budget
$480,000
Abstract
The goal of the project is the development of adaptable and successful native seed mixes viable to South Texas. These native seed mixes will be made available for commercial growers to supply the demand for native seed by public and private land managers and the development of effective planting strategies and revegetation techniques for this area of the state.
Abstract
The primary objective of this project is to provide documentation of the stormwater quality benefits of the vegetated sideslopes typical of the common rural highway cross section. The 2002 TxDOT Summary reports 79,361 centerline miles of state maintained ROW. Of these more than 70% have rural type cross-sections. That is the roadway surface is designed to drain directly from the surface of the road to a vegetated roadside. Water is then collected in a vegetated channel (borrow ditch), and conveyed to a natural creek or constructed drainage way. It is important that these benefits be documented so the roadside can be used as part of the design for meeting stormwater quality requirements. Doing so can significantly reduce the size and expenditure on expensive, end-of-channel structures and basins. The study will document the pollutant removal of roadside vegetation by installing passive stormwater samplers at the edge of pavement and at various distances across the vegetated areas. Collection troughs will be installed to direct runoff to these samplers from a width of the roadside cross-section sufficient to guarantee representative samples. Multiple sites are proposed to increase the confidence in the observed pollutant reductions. The sites will be located in two geographic areas to assess the effect of different vegetation assemblages and slope on pollutant reduction.

Research Products
- Table of performance characteristics of grass shoulders
- Design guide recommendations for estimating the WQ benefits of grass shoulders
- Recommendations on how PFC can reduce environmental impacts of highway runoff
Abstract

Phase II Rules of the National Pollutant Discharge Elimination System (NPDES/TPDES) require that issues of stormwater quality be addressed for all new construction and reconstruction. In many cases that means retrofitting of existing urban rights-of-way. In these conditions, the acquisition of additional right-of-way is cost prohibitive or would prove socially disruptive. In these situations, it will be necessary to resort to underground stormwater treatment structures. At this time there are approximately fourteen different proprietary stormwater quality treatment structures being marketed for this purpose. While these structures are effective in some applications they are expensive when compared to other precast units such as pipe and box culverts. In addition some require significant head to operate properly and they have special maintenance requirements to ensure continued proper operation. The purpose of this project is to develop simple effective stormwater quality treatment structures that are composed of off-the-shelf materials including pipe and box culvert sections with specialized inlet and outlet controls. These structures will be designed for low head loss and will affect efficient, low maintenance and cost effective stormwater quality treatment in limited right-of-way conditions.

Research Products

- Design Guidance Document for Non-Proprietary Small Footprint BMPs
- Standard details of entrance and control structures
- Specifications for materials and construction

Research Universities and FY 2006 Budget

<table>
<thead>
<tr>
<th>Center for Transportation Research</th>
<th>$89,974</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Transportation Institute</td>
<td>$82,628</td>
</tr>
</tbody>
</table>

Total Project Budget

$574,369
Abstract
A recurring problem for TxDOT involves low-water crossings and other low-height structures crossing streams within the Edwards Plateau (Hill Country) region of central Texas. These crossings are often subject to large or even catastrophic flood flows. The flows typically exhibit high velocities, and a large concomitant flux of gravel and cobble size bed load. This bed load often covers or buries low-water crossings, damages structures, and contributes to partial or complete failure of structures. Often roadways after floods become impassable or hazardous to public travel and restrict the activities of emergency services until TxDOT maintenance crews are able to clear crossings and make necessary repairs or even structural replacement. TxDOT staff reports that considerable and hard-to-predict maintenance expenses result from bed-load removal and associated repairs. Also the costs of complete structural replacement are large; the costs of replacing a single two-lane low-water crossing can exceed half-million dollars. The multi-institution six-year research described in this proposal is intended to document the geographic extent of the problem, physical causes (natural or otherwise), and suggest mitigation efforts or design changes that TxDOT engineers can implement for cost-effective risk-mitigated stream crossings in the affected area.
Abstract
There is a growing public demand for safer streets and highways. In response to this demand, state and national transportation agencies have developed safety programs that emphasize public education, accelerated highway renewal, community-sensitive street systems, and innovative technology to facilitate safe highway design. Highway safety concerns are also evident in Texas. Crashes in Texas continue to increase and currently exceed 300,000 per year. Nearly 4000 motorists die annually on Texas highways. A multi-year project is needed to develop and maintain a comprehensive, state-of-the-art assembly of resource documents, workshops, and reference materials dealing with the safety effects of geometrics. The successful incorporation of this information into the highway design process will require an extended commitment to research, synthesis, and training. The activities of this project will be coordinated with other ongoing safety research projects sponsored by the State of Texas and national transportation agencies. This project will ensure that the results of these state and national endeavors are well disseminated and implemented within TxDOT for the benefit of Texas motorists. A goal of this project is to reduce crashes on Texas highways by incorporating safety considerations at key steps in the highway design process. This goal will be achieved by providing Texas engineers with highway safety design guidance documents, safety awareness workshops, and a highway safety design clearinghouse. These sources of information would address:
(1) new construction, major reconstruction, and 3R construction (resurfacing, restoration, rehabilitation),
(2) all highway facilities (freeway, arterial, collector), and
(3) all highway travel modes.

Research Products
- Roadway safety design workbook
- Calibration factors handbook
- Interim roadway safety design workbook
- Procedure for using AMFs to evaluate design
- Rural, two-lane roads workshop materials
- Rural, multi lane highways workshop materials
- Safety performance monitoring procedures
- Urban & surban arterial highways workshop materials
- Roadway Safety Design Synthesis

Research Universities and FY 2006 Budget
Texas Transportation Institute - $180,881

Total Project Budget
$998,577
Abstract

Curved highway segments often use superelevation to help balance centrifugal forces on vehicles. Zero cross slope occurs in transitions to and from superelevation. TxDOT design procedures require longitudinal slope through these sections, but does not provide guidance on the minimum longitudinal grade that is necessary to promote highway drainage. The research will provide guidance on necessary minimum horizontal grade through superelevation transitions, and on inlet spacing in the superelevation zone. Guidance will be developed through three major research efforts. The first effort, listed as Task 1, consists of review of experimental and modeling literature on overland flow, gutter flow, and inlet performance. The second major effort, listed as Task 2a, will involve physical hydraulic modeling of overland pavement flow on flat and non-plane (warped) surfaces, including zero cross slope and variable rainfall intensity. The third major effort, listed as Task 2b, will involve development and evaluation of modeling tools for analysis of overland flow on highway pavements, including gutter flow and inlet performance. This integrated research program will provide recommendations on minimum longitudinal grade at zero cross slope and inlet spacing through superelevation transition.

Research Products

- Design guidelines for minimum longitudinal slope through superelevation transitions
- Estimated benefit of research calculated in terms of potential safety, cost savings (to TxDOT), and project delivery
Abstract

Texas and many other transportation agencies are under increasing scrutiny and pressure to utilize native plant seed on the roadside and to remove introduced species from the seed mixes. Some of the most recent pressure is the result of Executive Order 13112 of February 3, 1999, on Invasive Species. The purpose of this project is to investigate whether TxDOT’s standard seed mix needs any modification to better address the issue of invasive species while the primary goal of erosion control can still be well achieved. The research will focus on documentation of (1) the successional process using TxDOT seed mix and seeding procedure on field laboratory test plots and actual roadsides, (2) erosion control properties of vegetation on 12 new plots seeded with TxDOT standard seed mix, and 10 existing plots originally seeded with non-TxDOT seed mix, and (3) the impacts of mowing on establishing and established grass communities. It is anticipated by the research team that outcomes of this project not only provide scientific evidence to support TxDOT’s mission on roadside vegetation management but also create training and educational videos and brochures to enhance TxDOT personnel’s understanding of TxDOT’s mission on roadside vegetation management.
As more and more TxDOT projects are located in highly congested metro settings, many such projects require that adjacent utilities be relocated to make room for new or expanded roadway facilities. The relocation of utilities prior to construction is a highly challenging operation from many perspectives. As a result of such complications, TxDOT’s task of managing utility relocation is daunting and fraught with risk and uncertainty. One major strategic approach that has emerged over the last 15 years is for state DOTs to combine utility relocation work with the construction contractor’s scope of work, thereby eliminating or reducing some of the associated complications and risks. This approach is referred to in this study as the Combined Contractor Scope approach, or CCS. While many benefits can result from the CCS approach, it does have its disadvantages and own set of challenges. In addition, given the complications, there is a significant need for a decision support tool to provide guidance to TxDOT decision makers as to when CCS should be applied. The challenges in implementing the CCS approach can also vary widely and such challenges need to be defined and analyzed, and associated needs for implementation supports need to be identified. For example, TxDOT needs factual information and guidance on how to best "sell" the CCS approach to reluctant utilities. Thus, key components of this proposed research are to quantify and document CCS advantage/disadvantage trade-offs, better understand those project circumstances with which the benefits of CCS can be leveraged, and better understand how CCS-related concerns of utilities can be most effectively addressed. To accomplish this, a wide variety of information sources will be considered and previous CCS implementation history will be thoroughly examined from both DOT and utility perspectives.
Abstract

The Utility Accommodation Rules (UAR) prescribe minimums relative to the accommodation, location, installation, adjustment, and maintenance of utility facilities within the TxDOT 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 in the field that are not covered by the rules. Currently, there is no statewide standard for special provision structure, style, or content. As a result, several different versions of special provisions, many of them containing similar information, exist around the state. There is also a need to review utility relocation cost data, evaluate utility industry cost indexes, and develop a procedure and corresponding listing of unit construction costs for utility installations within the highway ROW. To address these issues, the proposed research will review specifications and special provisions for utility installations, review relevant industry specifications and standards, develop recommendations for special provisions and potential changes to the UAR, review utility relocation cost documentation, survey utility industry construction cost data, develop representative unit construction costs for utility installations, and prepare and submit products and guidelines on how to implement those products.

Research Products

- Draft Special Provisions and Recommendations for Specifications for Utility Installations at TxDOT
- Recommendations for Changes to the Utility Accommodation Rules
- Methodology for Estimating Unit Costs for Utility Installations within the ROW
- Estimated Benefits of the Research

Research Universities and FY 2006 Budget

Texas Transportation Institute - $133,960

Total Project Budget

$240,580
Abstract
Because emissions that lead to the formation of ozone have distinctive temporal patterns and the chemistry of ozone formation is non-linear and introduces time lags between emissions and ozone formation, it is not immediately clear whether emission controls that are effective for meeting the 1-hour ozone National Ambient Air Quality Standard (NAAQS) will be effective in meeting the 8-hour NAAQS. Therefore, as the transition is made between the 1-hour and 8-hour standards, several critical questions arise:

1) Will emission control strategies for mobile sources, that have been adopted in the State Implementation Plans for reducing ozone concentrations averaged over 1-hour, be equally effective in reducing 8-hour averaged ozone concentrations?

2) What is the magnitude of emission reductions from potential new mobile source control measures and how will these measures affect 1-hour and 8-hour averaged ozone concentrations in eastern Texas?

This project will address these questions using the Comprehensive Air Quality Model with Extensions, which is the only photochemical grid model currently used by the State of Texas for developing air quality plans. In addition, a Portable Emission Monitoring System will be used to quantify in-use emissions from selected non-road mobile sources projects. The proposed research will provide a foundation for effective transportation and air quality policy decisions in eastern Texas.

Research Products
• Recommendations from the PEMS study
• Recommendations of the effectiveness of emission control strategies under both the 1-hour and 8-hour ozone standards.
• Summary of research benefits.

Project - 0-5191
Investigation of Control Strategies for 8-Hour Ozone Standard

Start Date - 09/01/2004
End Date - 08/31/2006

Program Coordinator
Dianna Noble, ENV

Project Director
Heather Evans, ENV

Project Advisors
Christopher Kite, TCEQ
Dean Wilkerson, ISD
Don Lewis, GSD
Janie Bynum, TPP
Jim Smith, TCEQ
Mark Hodges, TPP

Research Supervisor
David Allen, CTR

Research Universities and FY 2006 Budget
Center for Transportation Research - $160,750

Total Project Budget
$311,082
Abstract
Toll equity and Regional Mobility Authorities (RMAs) are voter-approved financial tools to leverage limited state transportation funds and are considered key tools by Governor Perry to build needed transportation infrastructure in Texas sooner. Potential benefits for TxDOT include fiscal savings as RMAs take responsibility for developing infrastructure projects, reduced maintenance expenditures associated with reduced traffic on department facilities, and supplementary revenue.

Environmental justice requires that a transportation agency determine if a program, policy, project or activity will impact minority or low income populations disproportionately. Since no federal guidance exists on environmental justice and tollways, the focus of this research will be on developing and recommending an approach that can be used to determine whether minority and low-income communities are impacted disproportionately by (a) converting existing roads to toll roads, (b) constructing new toll roads, and (c) operating a project that has been approved to receive federal funding or is currently under construction as a tolled facility.
Abstract
Roadside safety devices perform the important function of shielding errant motorists from roadside hazards such as non-traversable slopes and fixed objects. In order to maintain the desired level of safety for the motoring public, these safety appurtenances must be designed to accommodate a variety of site conditions, placement locations, and a changing vehicle fleet. As changes are made or in-service problems encountered, there is a need to assess the compliance of the specific safety device with current vehicle testing criteria, and modify the device or develop a new device with enhanced performance and maintenance characteristics. Roadside safety issues will be identified and prioritized for investigation under this study in conjunction with TxDOT personnel. The selected safety problem will be evaluated through crash data analysis, computer simulation, and full-scale vehicular crash testing as appropriate. Factors such as impact performance, maintenance, and cost will be considered. Each roadside safety issue will be addressed with a separate work plan, and the results will be summarized in an individual research report. Implementation may be in the form of new guidelines or procedures incorporated into appropriate design manuals and/or new or revised standard detail sheets.

Research Products
• Drawing of new or refined hardware system, or guidelines and procedures for roadside safety issue studied in FY 2005
• Drawing of new or refined hardware system, or guidelines and procedures for roadside safety issue studied in FY 2006
• Drawing of new or refined hardware system, or guidelines and procedures for roadside safety issue studied in FY 2007
• Benefits of Research expressed in qualitative and quantitative terms
Abstract

Native varieties of grasses, having evolved over many eons, have clearly demonstrated their ability to withstand harsh environmental conditions and create stable vegetation communities. The Texas Department of Transportation (TxDOT) has been seeding native grass species along with adapted grass species as part of their vegetation establishment program for many years. Over the past decade, the use of native grasses has greatly increased as more people have become aware of their restoration and habitat advantages as well as their beauty. TxDOT would like to test the feasibility of using an all-native species seeding mix for use in roadside vegetation establishment in roadway construction projects. This study surveys available native grass species and tests selected varieties as part of a mix under roadside conditions to determine which if any, may be desirable additions to the current seeding program. The report discusses the issues related to the nature of native grass culture within the roadside environment and includes guidance on the use of native grasses in the roadside.
Abstract
TXDOT has experienced failures of all 10 propulsion engines used in their Galveston Ferry Operations after switching to TxLED. Thus, TXDOT was forced to switch their GFO ferries back to conventional diesel fuel. In order to meet their commitments, TXDOT needs to develop a solution to the problems with these engines when using TxLED. This project consists of two tasks. Task 1 will be an evaluation of the effects of the lube oil on engine failures when using TxLED. One or two lube oils will be selected for sea trials. TXDOT will test the use of this/these lube oil(s) when operating on TxLED. UT will conduct simultaneous tests in a different engine. Task 2 will be an analysis of factors other than the lube oil that might result in these engine failures. Up to four solutions for GFO sea trials will be recommended. The results of all sea trials will be evaluated.

Research Products
- Recommended low-ash oil(s) for testing via sea trials
- Assessment of the ferry locomotive-style EMD engine failure modes, with recommendations for solutions to be tested via sea trials
Abstract

Providing the public with safe transportation facilities, such as highways, is a primary objective of state departments of transportation. The construction of highways requires a significant amount of right-of-way acquisition—a complicated, multi-stage process involving numerous participants. One stage, the appraisal of the real estate, is a determination of the value to be paid by the department of transportation to fully compensate the landowner for the loss of land and resulting severance damages incurred. Variations in the value placed on the real estate often exist between departments of transportation and the landowner involved and even between two different appraisers evaluating the same or similar piece of property. As discussed in NCHRP Report 126, "the most important basic reason for divergences in estimates of value is the nature of the value itself. Value is a subjective phenomenon...Real estate valuation is an art that calls for the exercise of experienced judgment based on a logical and justifiable approach; it is an observational process-by no means an exact science." Because individuals with varying degrees of experience, knowledge and background will be employed to perform land appraisals for right-of-way acquisition, there will inevitably be differences between two independent values placed on the same or similar pieces of property. And, though technological advances and institutional experience have decreased the prevalence and magnitude of these differences over the last few decades, the problem still exists. The objective of this project is to develop an electronic appraisal system that can be used to store, transmit, manage, and analyze appraisal data for purposes of improving the review process and therefore reducing the occurrence and effects of variations in land appraisal values. The system will ultimately streamline the right-of-way acquisition process by providing vital information to decision makers at state departments of transportation. As a result of this study, appraisers and appraisal reviewers will be able to access and analyze appraisal information in a more efficient way.

Research Products

- Project Plans
- Electronic Appraisal Prototype System
- Prototype Documentation
RMC 4 - Overview
## RMC 4 – New Starts

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5235</td>
<td>Determining Nighttime Driver Signing Needs</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5238</td>
<td>Improved Temporary Traffic Control Guidelines For Urban Freeway Interchanges</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5251</td>
<td>Vibration Reduction and Control for Traffic Cameras</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5256</td>
<td>Use of Symbols and Graphics on Dynamic Message Signs</td>
<td>2/29/2008</td>
</tr>
<tr>
<td>0-5257</td>
<td>Strategies for Managing Transportation Operations Data</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5278</td>
<td>Managing Freeway Operations During Weather Events</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5284</td>
<td>Feasibility and Guidelines for Applying Managed Lane Strategies to Ramps</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5326</td>
<td>Improved Techniques for Traffic Control for Freeways and Work Zones</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5422</td>
<td>Ramp Treatment and Dynamic Closure Strategies for Incident Traffic Management</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5424</td>
<td>Analytical Enhancements to PASSER V for Arterial and Access Management</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5439</td>
<td>Identifying and Testing Effective Advisory Speed Setting Procedures</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5446</td>
<td>Guidelines for Signs and Markings on Toll Roads</td>
<td>10/31/2007</td>
</tr>
<tr>
<td>0-5507</td>
<td>Enhancements to Platoon Identification and Accommodation (PIA) System for Intelligent Control at Isolated Traffic Signals</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>Project Number</td>
<td>Title</td>
<td>End Date</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>0-4471</td>
<td>Evaluation of Horizontal Signing Applications</td>
<td>10/31/2005</td>
</tr>
<tr>
<td>0-4701</td>
<td>Traffic Control Device Evaluation and Development Program</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-4750</td>
<td>Long-Term Research into Vehicle Detector Technologies</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4813</td>
<td>Alternative Signing for Advisory Speeds on Freeway-to-Freeway Connectors for Vehicles with High Centers of Gravity</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4962</td>
<td>Development of Guidelines for Hurricane Evacuation Signing and Markings</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4965</td>
<td>Rural Two-Lane Roadway Crash Analysis</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4986</td>
<td>An Assessment of Frontage Road Yield Treatment Effectiveness</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5003</td>
<td>Development of TxDOT Procedures and Specifications for Testing Device Compliance to NTCIP Standards</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5079</td>
<td>Use of Traveler Information to Enhance Toll Road Operations</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5089</td>
<td>Raised Pavement Marker Improvements</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5090</td>
<td>Analysis of Edge Line Treatments</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5113</td>
<td>Improving Intersection Safety and Operations Using Advance Warning of End of Green System (AWEGS)</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>
### RMC 4 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
</table>
RMC 4 - New Starts
Abstract

TxDOT has sponsored research in the past that supports effective use of retroreflective sheeting for traffic signs. However, constant changes such as vehicle design (size and headlamps) and driver aging creates a need to evaluate sheeting performance in terms of nighttime driver needs. This is especially needed with an increased number of different types of retroreflective sheetings becoming available. Instead of evaluating retroreflective sheeting materials as they enter the market, this project is intended to develop a nighttime driver needs specification for traffic signs. The intent is to eliminate the need to evaluate retroreflective sheeting materials as they are introduced to the market and provide users and industry with a performance-based specification that can be used to select and design the best available sheeting to meet the needs of nighttime drivers. This project is also intended to consider innovative signing materials such as electroluminescent or photoluminescent signing technologies. These materials will be considered in terms of factors such as costs, durability, and ability to meet the nighttime driver needs.

Research Products

- Recommendation of a sign sheeting specification based on night time driver needs, which must be in a form that can easily be incorporated into the TxDOT Departmental Material Specifications.
- Test procedures which can be used for pre-qualification and routine testing of the sheeting, which will ensure the quality needed.
- Recommended application procedures
Abstract
The objective of this project is to provide the Texas Department of Transportation (TxDOT) with improved guidelines and traffic control standard sheets regarding the handling of pedestrians in work zones in order to meet the requirements of the Americans with Disabilities Act (ADA). This project is formulated around a work plan that involves:

- A review of federal and state policies, guidelines, and standards detailing the accommodation of pedestrians in work zones,
- Focus groups to ascertain the information and guidance requirements of pedestrians in a work zone environment, including special-needs pedestrians,
- A series of evaluations of the pedestrian components of Texas work zones, and
- An in-depth investigation of potentially innovative technologies or strategies to improve the handling of pedestrians in work zones.

These efforts have the potential to provide new insights into the interaction between pedestrians and work zone traffic control devices, determine which potentially innovative technologies and/or strategies can be of value as part of a temporary traffic control plan, and help determine appropriate recommended guidelines and temporary traffic control plan sheets that: meet the ADA requirements, are useful and helpful to pedestrians, and are of value to TxDOT.

Research Products
- Recommended guidelines to improve the handling of pedestrians in temporary traffic control situations.
- Recommended traffic control standard sheets for the placement of work zone traffic control devices for pedestrian situations in accordance with the Americans with Disabilities Act.
Evidence exists to suggest that drivers often have difficulty in navigating through work zones that occur within the vicinity of complex urban freeway interchanges. The numerous existing guide signs, presence of short auxiliary lane segments, multiple lane exits, high merging traffic, and other conditions in the work zones present complex driving situations and place considerable work load on drivers. Driver work load and driving complexity increases even more when temporary travel paths configured with channelizing devices are in conflict with existing guide signs. It is often difficult to convey lane closure, travel paths, and other warning information using traditional temporary traffic control signs and temporary pavement markings. These difficulties are experienced at both long-term construction and short-term maintenance activities. Meanwhile, selection and maintenance of pavement markings can be very difficult in long-term construction work zones. A pavement marking selected for a given project may not be durable enough to provide motorists adequate delineation through an interchange during the entire time it is in place. Conversely, a marking product may be difficult to remove completely in other applications, which can potentially confuse drivers attempting to traverse the work zone after a major traffic switch. Both cases can lead to driver confusion and safety/operational problems through the work zone. Because of these concerns, objectives of this research project are the following:

1. Improve temporary traffic control (TTC) guidelines to improve motorist path guidance and way-finding through urban freeway interchange areas; and
2. Improve guidance on selecting appropriate pavement marking materials in work zones.

Research Products
- Guidelines for improving temporary traffic control at urban freeway interchanges
- Application guidelines for pavement markings in work zones
- New or revised traffic control standard sheets
Abstract
This project will aim at developing two low cost high efficiency image stabilization devices and algorithms to correct images transmitted from the CCTV cameras to traffic management centers and to eliminate the requirements of high stiffness and strength for the camera poles so that lighter poles can be used. To achieve these objectives, it is proposed to develop a real time computer image processing algorithm and mechanical device(s) and to conduct a series of experimental and field vibrations tests on the cameras and supporting poles. The laboratory tests will employ the existing pole test setup for the ongoing TxDOT Project 0-4470 "Development of Design Criteria for CCTV Camera Poles", which consists of a 20 ft steel or FRP pole attached to the concrete base that is bolted to the laboratory reaction floor. A camera will be installed on the tip of the pole, and the test pole will be subjected to simulated wind induced vibrations. Sixty tentative test specimens (test poles) are selected based on finite element model (FEM) analyses of the pole developed in Project 0-4470 by varying pole's geometric variables and obtaining their displacement profile when subjected to different wind speed. The test specimen will then be displaced accordingly, and it will be allowed to vibrate in free vibration mode by considering mass and stiffness of each pole. This means that constraints of natural frequency and period of vibration of the system will be imposed on the pole during free vibration test ("constrained free vibration"). This process simulates the free vibration of different poles with different geometry and length using one test set-up. The camera installed on the pole will transmit the images to the monitors installed in the laboratory from which the effects of developed image processing algorithm and mechanical damping device on the image corrections can be evaluated. It is proposed to conduct at least 40 experiments: twenty tests using image processing and twenty tests using mechanical device(s). This would allow investigators to identify effects of developed image processing algorithm and mechanical devices separately on the stabilization of the images. This process will be used to calibrate the computer image processing algorithm and mechanical device(s) through a trial process in which the developed devices can be calibrated for the variety of poles with different dimensions. Upon calibrating each device separately, combined image stabilization tests will be conducted on the twenty test cases by installing the mechanical damper and using the proposed image processing algorithms to stabilize the images. Investigators will consult Program PC, PD, and PAs of this project to identify several CCTV cameras/poles throughout the State of Texas for field experimentation. Based on the findings of laboratory testing, the developed image processing algorithm, mechanical device, or combined devices will be field tested for a period of at least three months to capture the effects of different wind speeds on camera’s vibration and image correction. Finally, during both laboratory and field experimentations in which light weight poles are included, the images from high strength and stiffness poles without devices (current poles) will be compared with images obtained from a light pole with application of mechanical and electrical devices when subjected to identical loading. This will result in information to enable TxDOT to install CCTV cameras on light traffic poles and bridge signs.

Research Products
- Manual for developed mechanical vibration device and installation procedures
- Manual for developed electrical vibration device and installation procedure

Research Universities and FY 2006 Budget
University of Texas at Arlington - $123,508

Total Project Budget
$241,508
Abstract

Text messages are the predominant means by which information is conveyed to motorists via dynamic message signs (DMSs). However, the development of full-matrix and other DMS hardware technologies has made it possible to display symbols and other graphics features to the motoring public. This type of capability may offer potential benefits to TxDOT traffic management center operators, particularly at decision points such as major interchanges, toll facilities and other major routing decision points and in tourist and border areas where there are concerns over motorist understanding of English text messages. However, research is first needed to develop specific human factors guidelines for the use of these capabilities. Questions concerning motorist comprehension and information loading must be answered. The purpose of this project is to develop guidelines for TxDOT regarding symbols and graphics that are acceptable for use on DMSs, and the design characteristics associated with them. As part of this project, researchers will:
1. Determine and prioritize the symbols and graphics of greatest potential use on DMSs;
2. Conduct focus group studies and human factors laboratory studies to determine legibility distances, motorist comprehension, and informational demands of potential DMS symbols and graphics; and
3. Develop guidelines regarding acceptable symbols and graphics for use on DMSs which can easily be incorporated into TxDOT’s Dynamic Message Sign Message Design and Display Manual.

Research Products

- Guidelines for the Use and Application of Symbols and Graphics on Dynamic Message Signs

Research Universities and FY 2006 Budget

Texas Transportation Institute - $134,700

Total Project Budget

$332,000
Abstract
The operation and management of the transportation network generates 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. While TxDOT has devoted considerable resources to address data management issues, there is a need for a more holistic approach to transportation operations data management to fully realize the potential offered by the data. In particular, research is needed to document current operations data management practices at TxDOT and outline strategies to manage operations data more effectively. This research project conducts an evaluation of current operations and data management practices at TxDOT, documents operations, and data management practices and plans at other states, documents operations personnel data user needs, builds a conceptual data model for transportation operations data management, outlines strategies for managing the data, and formulates implementation guidelines.

Research Products
- Conceptual data Model for Transportation Operations Data
- Strategies for Managing Transportation Operations Data

Research Universities and FY 2006 Budget
Texas Transportation Institute - $118,475

Total Project Budget
$118,475
Abstract
Weather events affect traffic on every roadway in the nation and have concerned transportation agencies for many years. Even minor weather events can cause slick pavement, reduce travel speeds, increase speed variability, increase delay, and increase the potential for crashes. Many states, including Texas, are implementing weather monitoring systems to help prepare for inclement weather and operate the transportation system during major weather events. The goal of this research is to help TxDOT develop a structured, systematic approach for managing traffic during weather events. This research project will provide TxDOT with a set of strategies and techniques for operating freeways during weather events. As part of the research, a concepts of operations document will be developed that will provide TxDOT districts with guidance on how to deploy and integrate weather-related traffic management strategies into their normal, everyday traffic management functions. Through a report, this research will provide a catalog to strategies that TxDOT can use to manage freeways during weather events. Specific documentation and diagrams will be developed that will show TxDOT and their software developers how to integrate weather-related traffic management data and control strategies into their ATMS and other freeway management control software.

Research Products
- Concept of operations for managing freeway and highways during weather events
- Catalog of traffic management techniques that can be used to manage freeways during weather events
- Framework of integrating weather information and management strategies into TxDOT’s ATMS and other freeway management control software

Research Universities and FY 2006 Budget
Center for Multidisciplinary Research in Transportation - $34,944
Texas Transportation Institute - $103,587

Total Project Budget
$138,531
Abstract

Current funding constraints and difficulty in gaining environmental and public approval for large-scale construction projects has forced TxDOT to continue considering alternative solutions to roadway widening to mitigate congestion. One area for potentially improving freeway performance is ramp locations. Current ramp treatments only address point demand. Applying managed lanes operational strategies to ramps could maximize existing capacity, manage demand, offer choices, improve safety, and generate revenue. This project will investigate the application of these demand management strategies to mainlane ramps and managed lane ramp operations during the peak period: i.e., "managed ramps". Such strategies could include peakperiod use of both mainlane or managed lanes entrance and exit ramps by user group, possibly influencing mode choice, enhancing mobility, improving safety in a freeway corridor, and helping ensure the integrity and free-flow operations of a managed lanes facility. This research will investigate (1) under what conditions should managed ramps be considered for both mainlanes and managed lanes based on relevant factors including target users in the corridor, congestion level, ramp spacing/density, ramp volumes, accident history, etc.; (2) assess the impacts and benefits of managed ramps; and (3) develop general guidelines and best practices for operating and enforcing managed ramps.

Research Products

- Guidelines for applying Managed Lanes Strategies to Ramps
- Managed Ramps Chapter for Managed Lanes Handbook

Research Universities and FY 2006 Budget

Texas Transportation Institute - $108,870
University Of Texas At El Paso - $19,748

Total Project Budget

$248,618
**Abstract**
Traffic management centers monitor the conditions of the roadways, respond to incidents, improve the flow of traffic and increase the safety of the freeway system. Many operational strategies are employed to meet those challenges. Currently, there is no methodology by which those operational strategies are assessed to determine their benefit and improve the overall decision-making process. When combined with an assessment mechanism, performance measurement concepts can be used to judge the effectiveness of various strategies. This can be applied to operational and emissions based strategies as well as to special situations, such as managed lanes. The aim of this project is not to determine which operational strategy should be applied to a given situation. The goal is to create a process which can collect, store, and produce the information necessary to enhance that decision-making process for the future, based on performance measurement techniques. By creating this process, and supplying the project deliverables, the research lays the foundation for making performance measurement an integral part of the capabilities of future versions of TxDOT’s Advanced Traffic Management Software. This enhances the core capabilities of TxDOT as well as the daily travels of millions of people in the state.

**Research Products**
- Prototype database structure for collecting, storing, and producing performance measures
- Prototype displays for ATMS performance measurement based assessment process
- Concept of operations for using operational and emissions based performance measures to assess freeway management strategies
Abstract
Bottlenecks can occur at lane drops, freeway merges, exit and entry ramps, and many other locations where there is a change in road characteristics. However, bottlenecks created by incidents and work zone lane closures, where relatively large speed variations and long queues can be expected, are particularly high-risk locations. A major safety concern associated with freeway bottlenecks is increased rear-end crash potential. According to a recent TxDOT study (1), rear-end type collisions comprise over half of all urban freeway crashes, and about one-third of work zone crashes. Depending on the speed differentials between queued and approaching traffic, rear-end collisions can be quite severe. However, many of them could be avoided by providing effective advance warning for vehicles approaching the end of slow or stopped queues. When freeway bottlenecks are caused by work zone lane closures, rear-end crash potential can also be reduced by effective merge control. Conventional work zone traffic control, that encourages early merge, works well in light traffic when congestion does not develop. However, at traffic volumes higher than capacity it may lead to excessive queues extending beyond the advance warning signs, thereby increasing the risk of rear-end crashes. Also, the early merge type control may lead to erratic maneuvers, and road rage among drivers under congested conditions. There are alternative merge controls, such as the Indiana Lane Merge and the Late Merge, but both have operational characteristics that limit their effectiveness under both congested and uncongested traffic flow conditions. A merge strategy that would perform well under both non-congested and congested traffic conditions is needed. This research will attempt to determine the most effective merge control for various traffic and roadway conditions, while providing effective warning messages to alert drivers of slow or stopped traffic ahead. It is envisioned that the Dynamic Late Merge system will be used for this purpose. The research will also determine and evaluate an effective advance warning strategy for off-ramp queue spillback. Findings of this research will provide TxDOT with standardized and tested messages/techniques that can be used to improve the effectiveness of traffic control on freeways/work zones, reduce traffic delays, and increase safety of the traveling public. The research team will expand on the "Selection Strategy Flowchart" which was developed in TxDOT Project 0-4413 (1), and will develop guidelines for the selection and appropriate use of alternative merge control strategies such as the Late Merge, and Dynamic Late Merge.

Research Products
• Field guide for construction personnel and area engineers: A concise field guide to aid construction personnel and area engineers in selecting appropriate advance warning techniques and messages, and alt. merge control strategies under various types etc..
Abstract
Non-recurrent congestion resulting from traffic incidents accounts for a significant portion of traveler delay in the United States. Effective incident management represents a critical opportunity to reduce the incident-related delay. One potentially underutilized approach for incident management is the use of ramp closure in combination with other ramp treatment strategies to better manage traffic flow during incidents. Implementing such closures, however, presents a very difficult problem. Special care must be given to ramp closure deployment as it causes significant disturbances to the traffic flow pattern in the area. Further, an integrated and comprehensive traffic management plan will have to be developed and implemented in coordination with ramp closure to ensure that ramp closure is a viable form of incident management. The objective of this research is to develop a formal analysis procedure for evaluating ramp closure strategies in combination with ramp treatment for traffic management and produce guidelines for successful implementation. In addition, as a necessity of these objectives, improved and innovative techniques for incident duration prediction are critically required. The guidelines will consider the potential implementation solutions and their application for TxDOT. Of particular interest is the development of a guidebook to facilitate the selection of appropriate settings and deployment approaches for ramp closure.

Research Products
- Guidelines and best practice for closure of ramps in conjunction with ramp treatment during incident management
- Software- incident duration prediction models
- Training workshop for TxDOT personnel

Research Universities and FY 2006 Budget
Center for Transportation Research - $74,817
University Of Texas At El Paso - $45,183
Total Project Budget
$240,000
Abstract

The Texas Department of Transportation (TxDOT) and many other agencies in the U.S. prefer to time their traffic signals to maximize through progression for arterial traffic. Because of this need, the PASSER series of traffic signal optimization software have become an asset to these agencies. Historically used to develop new progression-based signal timings for a variety of traffic signal installations, PASSER programs have also been used to analyze intersection-related geometric improvements, predict the delay, fuel consumption, or air quality impacts of proposed improvements, or even analyze corridor-level traffic management issues such as access management. Recent access management analysis of several arterial roadways in Texas required the comparison of alternatives with different signal spacing, inevitably leaving some intersections unsignalized. Since PASSER, including recently developed PASSER V, software cannot presently analyze unsignalized intersections, it was necessary to use the Synchro traffic optimization tool for the analysis. However, as the Synchro tool is not designed to provide arterial progression, questions were raised about the usability of the results, since TxDOT would inevitably time signals along an arterial to achieve progressed flow. The objective of this project is to enhance PASSER V to provide a capability to analyze the impacts of unsignalized intersections, including driveways, located on signalized arterials. With this additional feature, PASSER V users will be able to make side-by-side comparisons between alternatives for projects including traffic management improvements or access management improvements. In such projects, different intersections are signalized or unsignalized to achieve various operational or safety improvement objectives. The development of an unsignalized intersection analytical model for PASSER V will overcome the limitations of existing procedures (i.e., such as those found in the Highway Capacity Manual) which make them inadequate to cover the range of conditions that can be analyzed by the PASSER V program.
Abstract

Many techniques are being used to separate managed lanes, many of which are tolled lanes, from free or unmanaged lanes. Choices among buffers, barriers, or post type delineators are typically based upon careful consideration of project specific needs and conditions. As the number of operating and planned projects employing some form of lane separation continues to grow, many agencies are developing significant experience. This project aims to harvest that experience as recommendations or "best practices" for choosing among available techniques for separating toll and free lanes. This will be accomplished through an inventory of toll lane, as well as managed lane, separation techniques with detailed characterizations of project-specific conditions. The project-specific condition characterizations developed through the inventory will be condensed to form a finite number of generically different scenarios and a set of evaluation criteria that could be used to choose among lane separation techniques. An Expert Panel will be selected from officials representing agencies having experience with managed or toll lane separation projects. Led by an experienced practitioner, the Expert Panel will be guided through an evaluation process which will produce ratings of candidate lane separation techniques for a carefully designed yet comprehensive array of project scenarios. After review by the Project Advisory Committee, the Expert Panel ratings will be converted to "If . . . .Then" statements describing project characteristics and prioritized lists of "best practice" separation techniques.
Abstract

Research has shown that the average crash rate for horizontal curves is about three times that for a tangent road section. Warning signs are intended to improve roadway safety by providing the driver with a warning of conditions that may not be apparent or expected. However, several research projects conducted in the last 20 years have consistently shown that drivers are not responding to the alignment warning signs nor complying with the advisory speed plaque. These researchers have advocated the need to establish a procedure for: (1) identifying when a curve warning sign and advisory speed plaque is needed and (2) selecting an advisory speed that is consistent with driver expectation. They also recommend the uniform use of this procedure on a statewide or nationwide basis such that driver respect for alignment warning signs is restored and curve safety records improved. The objectives of this research are to: (1) develop guidelines for determining when advisory speeds are needed to maintain safe operation, (2) develop criteria for identifying appropriate advisory speeds, and (3) develop a cost-effective engineering study method for determining the advisory speed needed for a given curve. The proposed research will focus on horizontal curves that exist on rural highways in Texas. However, to the extend possible, it will also address curves on urban highways, urban streets, and interchange ramps. The proposed research includes consideration of the signing needs of both passenger car and truck drivers.
Abstract
As toll facilities become more prevalent in Texas, it becomes more important to standardize the signing and markings used specifically for toll roads. Traffic control device standards specific to toll facilities are virtually non-existent for either cash toll plazas or open-road electronic tolling facilities. Electronic toll collection systems pose unique traffic control device challenges. Information concerning acceptable forms of payment needs to be conveyed in advance of all access points to reduce violations and erratic maneuvers at entry. Information concerning limited use toll stickers, or other alternatives to account-linked transponders, may need to be conveyed as well. Facilities combining cash plazas, which require traffic to stop, with electronic collection lanes, where traffic can travel at highway speeds, pose safety concerns due to speed differentials, weaving and merging. The first part of this project would be to evaluate current toll road signing practices and identify deficiencies and inconsistencies. The second part of this project would conduct driver comprehension research of proposed sign designs and sign sequences. Pavement marking longitudinal striping patterns and horizontal signing; i.e., words and symbols on the pavement, would also be studied. Many toll facilities are experimenting with novel colors of signs and the use of toll authority logos on signs and pavement markings. The effect of these treatments on drivers has not been assessed. The project will produce a document containing guidelines for traffic control devices as a function of facility type. This document will serve roadway planners, designers, and operators in traffic control device selection and policy. The project will also produce a fieldbook intended for installation and maintenance personnel to assure consistency in design and placement of traffic control devices.
Abstract
TxDOT Project 0-4304 developed a platoon identification and accommodation (PIA) system for use at isolated signals where platoons of vehicles on the major approach are frequently forced to stop in order to serve a few vehicles on a minor approach. The PIA system consists of custom software and off-the-shelf hardware. Its platoon detection algorithm uses vehicle presence and speed data obtained from a speed trap installed upstream of the stopbar. The system schedules low-priority preemption to progress the detected platoon through the intersection. In addition, it provides dilemma zone protection to these vehicles. The system monitors the real-time status of detectors and phases in the controller and takes appropriate actions to ensure that the minor movements are not unduly taxed. Field tests conducted at two sites demonstrated the potential performance and safety benefits of this system. The objective of this project is to enhance the PIA system for larger-scale deployment in Texas. Specifically, this project will: (1) refine the software and extend its algorithms for application to both major directions, (2) eliminate some hardware to reduce implementation cost and cabinet space requirement, and (3) install the refined system at two sites and conduct studies to quantify operational and safety benefits.
Abstract

Agencies have installed various types of treatments to separate toll lanes from general-purpose lanes at existing projects and are looking at options for future projects. Advice on the location of the access to and from toll lanes is also needed. This research project is to investigate the following two topics: access to and from toll lanes and location of access with respect to general-purpose lane ramps. Project implementation will include a summary report on locating the access to and from toll lanes. This product will allow TxDOT engineers to understand the tradeoffs in selecting the type and location of the access points to and from the toll lanes.

Research Products

• Draft wording (including guidelines, recommendations, tables, figures, etc.) for inclusion in TxDOT publications (e.g., Roadway Design Manual, Managed Lane Handbook) on access to and from toll lanes
RMC 4
Continuing Projects
Abstract
Dynamic message signs (DMS) are being deployed extensively in major metropolitan areas in Texas. It is important that messages being displayed on these signs across the state are formatted consistently from District to District so that the formats are transparent to motorists traveling in different parts of the state. At the same time, there are local issues and situations that arise which require distinct messages. Proper message design and application on these signs is a complex process. Although many messages can be pre-designed and called up from a message library when needed, transportation management center (TMC) operators must often modify existing messages or develop new messages in real-time to deal with the unique aspects of an incident or other special situation. The purpose of this project is to develop the logic and prototype of an automated message design system. As part of this project, researchers will:

1. Develop the logic (flow charts, conditional rules, etc.) needed to automate or provide decision support to the various parts of the DMS message design process.
2. Develop a proof-of-concept prototype of an automated DMS message design and display system.
3. Conduct feasibility and validation testing of the message logic and the prototype using operators from selected TxDOT TMCS.

Research Products
- Update to the Dynamic Message Operations Manual
- Updated prototype of an automated dynamic message design and display system
Abstract

Traditional pavement marking treatments consist primarily of edgelines, center lines, gore markings, and intersection lane assignment arrows. The placement of road guidance, warning, and regulatory information on the roadway surface can also be an effective traffic control device. This horizontal signing may be more noticeable to drivers than typical signs because it is directly in their line of vision. In addition, horizontal signing may be a more cost effective traffic control device because it eliminates the need for costly sign structures over multiple lanes of traffic in urban areas. Challenges to the use of horizontal signing include driver comprehension, visibility of the markings, traffic volume, and durability of marking materials. This research project will identify horizontal signing applications best suited to Texas roads for both urban and rural freeway applications. An evaluation of operational effects on traffic will assess the benefits of this traffic control device. Through a material test deck, the durability of different materials, application methods, focus groups, driver awareness and comprehension of horizontal signing, will be assessed.
Abstract
This five-year research project will evaluate numerous traffic control device issues and develop implementation recommendations based on the results. This project has been structured to address some of the unique considerations related to traffic control device research. Two of the most significant of these are 1) traffic control device research needs are sometimes identified in a manner that necessitates a quick response that does not fit into the normal research program planning cycle, and 2) individual traffic control device research needs are not always sufficiently large enough to justify funding as a stand-alone research project, despite the fact that the issue may be an important one.

The activities to be conducted in this project will be formulated on an annual basis, with the ability to add or delete activities at any time. The issues initially proposed to be addressed in the first year are: retroreflective signal back plates and sign posts, wider pavement markings, improved design for distance and destination signs, visibility of worker vests, methods for locating no passing zones, and improving speed limit sign conspicuity.
Abstract
Research has identified operational and safety concerns at preempted traffic signals near highway-rail grade crossings with active warning devices that can only be addressed by using advance preemption. Railroads typically only provide simultaneous preemption, unless the highway authority requests additional warning time, which is then provided by the railroad in the form of advance preemption. Providing advance preemption is significantly more costly than providing simultaneous preemption, and TxDOT typically carries this additional cost. Due to limited budgets and the increasing need to upgrade passive crossings with active warning devices, advance preemption is typically only provided to address primary safety concerns. The objective of this research is to investigate the feasibility of augmenting existing simultaneous rail preemption by providing non-vital advance preemption through the use of cost effective non-railroad equipment. The research will determine if a low-cost, non-vital advance preempt provided off railroad right-of-way can provide most of the benefits of advance preemption, while the simultaneous preemption provided by the railroad supplies the traditional safety-critical operation. Tasks will include investigating (i) alternative methods of providing non-vital advance preemption, (ii) how it can be used to improve signalized intersection safety and operations, and (iii) the benefits and cost of doing so.

Research Products
- System design document for providing non-vital advance preemption at grade crossings with simultaneous preemption
- Specifications for equipment needed to provide a non-vital advance preempt at grade crossings with simultaneous preemption
- Implementation guidelines for providing a non-vital advance preempt at grade crossings with simultaneous preemption

Research Universities and FY 2006 Budget
Texas Transportation Institute - $75,000

Total Project Budget
$315,611
Abstract

This research will build on findings of previous research such as projects 0-2119 and 0-1715. Because improvements in performance aspects and in functionality of non-intrusive vehicle detectors continue to occur at an ever increasing pace, there are reasons to continue testing of the most viable products and determine their interface potential with other components of TxDOT’s existing system. Like previous vehicle detector research, this research will test the latest and most promising non-intrusive vehicle detector technologies. However, its scope will be broadened to include an interface with TxDOT’s current ATMS system using contact closure inputs to current Local Control Units (LCUs) for collecting vehicle count, speed and occupancy data. The research will also investigate the feasibility of combining detector technologies. Detectors are already available that combine multiple technologies within the same housing and utilize the strengths of each technology with the goal of improved performance beyond what either technology alone could achieve.
Abstract
Significant deployment in the past 10 years of dynamic message sign (DMS) installations to enhance motorist communication and traffic management has occurred in urban areas of Texas and is beginning to be extended into more rural (non-urban) traffic environments. Evaluation of the performance of these systems is necessary under both critical (incident) and non-critical (normal) traffic operations to determine whether DMS improve traffic conditions and/or public perception. The objective of this research study is to develop guidelines and contingency evaluation methodologies that will allow operating agencies to effectively and objectively assess DMS performance both quantitatively and qualitatively with available data and resources. This objective will be achieved through a comprehensive investigation of DMS performance characteristics and associated measures of effectiveness and identification and/or development of appropriate methods for agencies to conduct DMS evaluations. The guidelines and evaluation methodologies developed will be tested and validated in both urban and rural case studies with final review and approval by a selected TxDOT advisory panel.

Research Products
• Guidebook detailing approach, procedures and priorities for evaluating DMS performance, including implementation module
• Application of the guidelines to three DMS-equipped travel corridors in the state
Abstract
The purpose of this project is to develop signing and pavement marking guidelines for implementation of a dual system of alternative curve warning and advisory speed signing for passenger cars and heavy trucks on freeway-to-freeway connector ramps. This research will build on previous projects that quantified the differences in vehicle operations on freeway-to-freeway connectors. The previous research found that the non-truck-driving motoring public (drivers in passenger cars, light trucks, and sport-utility vehicles) generally exceeds the posted advisory speed limit on freeway-to-freeway connectors (with a violation rate of 95-99%) and often by more than 10 mph. That same research indicated that there is a 5 to 10 mph higher difference between a driver’s maximum comfortable curve speed between passenger cars/SUVs and larger vehicles on most freeway-to-freeway connectors. Given the strong evidence that there is a significant differential between speeds that cars and heavy trucks can negotiate comfortably and safely, there is need for further research to investigate current signing and pavement marking practices and develop a dual-advisory speed signing scheme and implementation guideline that will address this differential.
Abstract
Historically, freeway traffic management software has been designed to allow the operator to react to incidents and congestion after they have already occurred. While reacting to unexpected events will always remain a critical part of freeway operations, freeway operators need to proactively manage traffic on the freeway to minimize the impact of events or even possibly preventing them from occurring in the first place. The purpose of this research project is to combine several existing research disciplines (such as traffic flow prediction and modeling) with real-time measurements of freeway performance to develop a tool that TxDOT can use to proactively manage traffic operations on the freeway. As part of this research, we will examine techniques and technologies that TxDOT can use, in conjunction with real-time and archived loop detector data, to forecast if and when traffic conditions are likely to produce incidents. We will also examine methods TxDOT can use to predict traffic flow parameters (such as speed, volume, and occupancy) 15 to 30 minutes into the future. We will develop and test a prototype tool that TxDOT can implement in their control centers that will combine these two models to predict potential problem locations, in real-time, before they occur.

Research Products
- Prototype simulation tool for predicting incidents and short-term congestion
- Users' guide for using prototype simulation tool
Abstract
It has been many years since a major hurricane hit the Texas coast and there are concerns about the ability of large segments of the coastal population to evacuate prior to the arrival of a major hurricane. One of the concerns relates to the signing and marking of hurricane evacuation routes. This project will evaluate various issues associated with signing and marking hurricane evacuation routes and will develop general guidelines to address the critical issues. In conducting the research, the researchers will assess the state-of-the-practice, identify operational demands, evaluate various attributes of potential hurricane signing and marking alternatives, assess the common attributes of hurricane evacuations and other types of evacuations, and develop general guidelines for signing and markings for hurricane evacuations.
Abstract
The Texas Department of Transportation (TxDOT) is responsible for the operation and maintenance of approximately 44,000 centerline miles of rural (5,000 and less population) two-lane secondary (State or FM) roadways. The State of Texas ranks first in rural roadway fatalities and eighth in rural roadway fatality rates among all states, based upon the most current available national crash data (2002). In several TxDOT Districts, the rural, two-lane, FM roadway fatal crash rate is 4 to 5 times the Interstate fatal crash rate in Texas. This project will conduct an in-depth study of traffic crashes on State system, rural, two-lane roadways to determine causal relationships and variables of influence to crash rate. The study will focus on fatal and serious injury crashes and conduct both longitudinal (time trend) and cross-sectional (variable comparative) analyses of all possible combinations of site and operational variables. It will specifically focus on paved surface widths less than 24 feet wide. Comparisons will be made by District for similar facilities and field inspections will be conducted as necessary. Engineering countermeasures to identifiable crash patterns will be determined and evaluated relative to the benefits versus costs of implementation. Guidelines for analysis procedures and a training module for implementation will be developed.

Research Products
- Guidebook for analysis of crash potential and countermeasures for rural, two-lane roadways based upon site and operational parameters
- Training module for implementation of guidebook

Research Universities and FY 2006 Budget
Center for Transportation Research - $80,000
Texas Transportation Institute - $86,767

Total Project Budget
$300,000
Abstract
A very important element of traffic operations and safety within the freeway interchange environment in Texas is the intersection area of the freeway exit ramp and the frontage road. The focus of this research project is the specific issue of yield treatments and related merging/weaving guidance in the freeway exit ramp-to-frontage road area. The current state-of-practice for such treatments in Texas varies widely and results in operational inconsistency and contributes to driver confusion. The purpose of this research project is to develop improved guidelines for yield treatments and related signing, striping and pavement marking alternatives being implemented in freeway exit ramp-to-frontage road areas throughout Texas. This goal will be achieved through a combination of statewide case studies and supplemental computer microsimulation analysis. These case studies will focus on the prevailing range of current applications for the urban/suburban one-way frontage road scenario. Relevant information collected, analyzed, and documented in this research project will include detailed geometric, operations and crash data. In order to maximize the implementation of beneficial results, this project will also include at least three regional forums for the Texas Department of Transportation (TxDOT) in major metropolitan areas in Texas. These forums will be used to convey an overview of the research project findings, allow for feedback/questions and answers from TxDOT personnel, and help streamline and/or otherwise expedite consistent implementation.
Abstract

As new National Transportation Communications for ITS Protocol (NTCIP) and other Intelligent Transportation System (ITS) standards-based devices and services become available, Texas Department of Transportation (TxDOT) will need procedures, mechanisms, and tools to ensure that these devices are not only compliant with TxDOT functional specifications, but that they are also conformant with NTCIP standards. This research project would assist TxDOT in developing a program for testing device compliance to NTCIP standards. The objective is to define a framework for testing and the approaches used to describe the extent to which testing is needed and the appropriate documentation for such testing activities. This research project would accomplish the following for TxDOT:

1. Assist TxDOT in the development of a comprehensive approach to testing ITS-related hardware and software to ensure conformance with national standards and compliance with TxDOT specifications.
2. Identify TxDOT testing needs and available resources to meet those needs.
3. Develop a framework, along with methodologies and procedures as needed, for conducting both laboratory and field testing of devices.
4. Assist TxDOT in evaluating options for testing of ITS hardware and software as part of procurement and construction projects.
5. Assist TxDOT in developing procedures and reports for documenting the results of the testing program.
6. Develop outlines for training courses that convey how to use and interpret the results of the testing program.

Program Coordinator
Carol Rawson, TRF

Project Director
Fabian Kalapach, TRF

Project Advisors
Charlie Farnham, TRF
David Danz, TRF
Steve Barnett, TRF

Research Supervisor
Robert DeRoche, TTI
Abstract
Pavement markings are considered by many to be the most valuable and important means of communicating roadway information to the driver. Longitudinal pavement markings provide a continuous stream of information about the roadway that cannot be provided by signs or signals. Over the past decade, many pavement marking materials and/or applications have been developed that are marketed as providing improved visibility under conditions of wet-weather or poor marking/pavement surface contrast. Wet-weather marking materials include, but are not limited to: wet-weather tapes, profile markings, large glass beads, and ceramic elements. TxDOT typically uses Reflective Raised Pavement Markers (RRPMs) to provide wet-weather visibility, thus RRPMs should be included in the wet-weather analysis. Contrast applications for light-colored pavement surfaces include, but are not limited to: leading black markings, trailing black markings, black borders around markings and combinations of leading/trailing/bordered applications. TxDOT and other agencies have experimented with many of these materials/applications, but there exists little formal documentation of quantifiable benefits or conditions; i.e., pavement, weather, etc., where these benefits are most likely to occur. This research is focused on the development of guidelines that can be used to select the most appropriate pavement markings application for wet-night conditions and lightcolored pavement surfaces. The results will be based on the results of visibility studies, material durability, costs, and installation and maintenance ease.

Research Universities and FY 2006 Budget
Texas Transportation Institute - $121,240
Total Project Budget
$274,600

Research Products
• Recommended guidelines for the application of wet-night and contrast pavement marking materials
**Abstract**

Supporting the development of toll roads allows TxDOT to add capacity and relieve congestion more quickly. However, traffic diversion to toll roads is often less than projected, impacting both toll revenues and system mobility. There is some evidence that providing motorists with information about congestion on competing non-tolled routes can enhance toll road financial prospects while improving traffic operations on the entire system. This research project will examine the types of information that would help users choose a toll road, potential increase in toll road share of traffic, operational effects on the non-tolled network, and technical and financial considerations for deployment. The results will provide new knowledge for the operation of 21st century Intelligent Transportation Systems (ITS).

**Research Products**

- Likely changes in Toll Road usage and resulting revenue
- Estimate improvements in throughput, speeds, travel, time, incidents, and air quality for selected region
- A strategy for deployment of traveler information mechanisms that will enhance toll road viability

**Research Universities and FY 2006 Budget**

Center for Transportation Research - $123,810

**Total Project Budget**

$243,534
Abstract
In recent years, there appears to have been a decrease in the quality and/or durability of retroreflective raised pavement markers (RRPMs). In this project, researchers will conduct laboratory and field tests of various RRPMs to determine if a correlation can be identified between the results of laboratory tests that are used for product qualification and routine testing and the actual life of RRPMs in the field. The laboratory tests are expected to encompass a range of tests, while the field tests will involve monitoring the performance of RRPMs that have been placed in the field. At the end of the project, the researchers will assess the correlations between the laboratory and field tests and develop recommendations for a material specification that defines the design criteria for RRPMs, a test procedure that can be used for qualifying RRPMs for use on TxDOT projects, and routine test procedure that can be used to monitor the quality of products that have been approved by TxDOT, and guidelines on the proper application of RRPMs.

Research Products
- RRPM Material Specifications
- Qualifying Test Procedure
- Routine Testing Procedure
- Application Specification

Research Universities and FY 2006 Budget
Texas Transportation Institute - $124,330

Total Project Budget
$300,385
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. Compared to other types of longitudinal markings, the effect of edge lines on safety and driver behavior has been much less investigated. However, such markings may have a positive impact on the reduction of crashes on two-lane rural roads, as well as on the general comfort level of driving. The proposed study will identify effective implementation areas for edge-line pavement marking on narrow roads. Corresponding with the major goals of edge line pavement marking, the proposed research focuses on complex investigations of their impact on driver behavior and reactions, including vehicle navigational and positioning issues, speed selection, and effect on driver visual perception. These processes will be investigated for different combinations of roadway design features and edge line treatments. Also, the study will consider the potential implementation of retroreflective raised pavement markers, as well as LED technology, for delineation of roadway edges. The proposed study targets development of inventories summarizing rural two-lane roads and characteristics relative to edge marking by TxDOT districts, and criteria for effective implementation of edge line pavement marking. The research aims to develop guidelines for the most cost effective application of edge line marking on two-lane roads. These guidelines will be designed to improve two-lane road traffic operation and safety.

Research Products

- Texas rural two-lane roadways inventory
- Database of roadway criteria for effective implementation of edge line pavement marking and RRPMS
- Summary of two-lane rural roadways by TxDOT districts, location and type of edge-line marking which can be implemented
- Guidelines for edge line marking on two-lane rural roadways
Abstract
Many urban freeways in Texas experience congested traffic conditions during peak periods. Freeway system expansion is a very expensive and time-consuming process. Consequently, alternatives other than construction of new facilities are desirable. The Texas Department of Transportation (TxDOT) has been implementing comparatively inexpensive methods to improve the existing freeways' operation, such as grade-separated (i.e., braided) ramps and modified ramp configurations via X-ramp interchanges and ramp reversals. Ramp reversal, replacement of an entrance with an exit ramp or vice versa, can help solve congestion issues between the exit ramp/frontage road intersection and the downstream cross street. Ramp reversal becomes an important consideration, especially when the situation involves traffic spilling back from an exit ramp onto the freeway mainlanes. TxDOT engineers need to have an updated methodology and evaluation results from previously implemented ramp reversal projects to assist in future decision-making. This project will investigate the benefits and impacts of ramp reversal projects. The project results will be of immediate benefit and use by TxDOT. Impacts that can be evaluated include operational, safety, and air quality benefits. Guidelines will be developed for TxDOT staff to assist in the evaluation and implementation of ramp reversal projects. This research will also investigate the benefits and impacts of X-ramp interchanges and braided ramps and develop guidance for their use.
Abstract
In Texas, traffic signals are being installed more frequently at high-speed rural intersections. Most of these intersections have posted speed limits above 50 mph and in some instances 70 mph. One of the major difficulties with traffic signal operation on high-speed approaches is related to dilemma zone on the high-speed approaches. Texas Department of Transportation (TxDOT) has been actively sponsoring studies to develop systems that alleviate difficulties faced by motorists in dilemma zones. One of the systems developed by the Texas Transportation Institute (TTI) for TxDOT was Advance Warning of End of Green System (AWEGS) in Project 0-4260. AWEGS provides a warning of five to six seconds to the motorists about the end of green by flashing beacons on the intersection approach. In project 0-4260 researchers identified some improvements to AWEGS performance. These included minimizing false detections, improving truck detection and treatment, and improving the advance warning signing. Improvements to the algorithm also include developing alternative operation modes due to detector failures and to consider the behavior of motorists to the AWEGS signs in the operation of AWEGS. TTI researchers will implement the identified improvements in AWEGS and deploy them at existing AWEGS locations in Waco and Brenham. Researchers also propose to use the lessons learned from improving AWEGS to implement AWEGS at a new location. By developing an Engineer and Technician handbook, TTI intends to prepare ready-to-use guidelines for TxDOT to install AWEGS at other locations to improve rural signal operations.

Research Universites and FY 2006 Budget
Texas Transportation Institute - $103,000

Total Project Budget
$243,170

Research Products
- Traffic engineer and technician handbook for AWEGS -
- Construction and Installation of AWEGS at a location to be identified.
Abstract
As the technological complexities of and public demands upon our ITS infrastructure increase, new opportunities and requirements arise regarding how best to manage existing ITS assets and select future deployments. This research project aims to support such decision making by developing methods that clearly relate sensor coverage (and other ITS data sources) to Dynamic Message Sign (DMS) performance via algorithms that predict freeway traffic time. This research is novel and critical as it addresses conditions where current travel time prediction algorithms typically perform sub-optimally, should produce methodologies that are more generally transferable state-wide, considers multiple sources of information, and explicitly treats sensor coverage and DMS location as input variables. In addition to better managing the existing ITS infrastructure, these methodologies will be employed in an evaluation framework to support future sensor coverage decisions and facilitate possible DMS deployments. Finally, the techniques will be rigorously calibrated and validated using multiple complete data sets (archived and simulated). The archived data include a set from El Paso and a separate set of data from New Jersey TRANSCOM (which represents one of the most complete, accurate and comprehensive dataset in the country collected for travel time prediction calibration purposes).

Research Products
• An operational guidebook for deploying travel time prediction capabilities, including required data characteristics, detector coverage, and real time operations issues. The instruction of using the archived ITS dataset will be included
• A calibrated online freeway travel time prediction model implemented via computer software
• A calibrated off-line detector coverage analysis tool implemented via computer software
• A training workshop for TxDOT engineers on the use of the developed models.
• An archived and organized ITS data and associated travel time data for future TxDOT use
Abstract
A project is proposed to determine the highway interchange types that would best be signed using diagrammatic signs. In addition, the best design of a diagrammatic sign will also be determined. These two issues will be addressed with existing research and practice and with original research testing Texas drivers from a number of different cities using computer based testing. A field study of drivers’ eye scanning behavior and lane selection at exits will complement this laboratory work. The field study will take place in an area where new or existing diagrammatic signs can be compared to standard signing in the same roadway geometry.
Abstract
In this project, the researcher will develop a highway speed vehicle-mounted TPPM thickness measurement devices based on the research results in Project 0-4882 so that the devices can be used in routine TxDOT project monitoring practice. The new version of TPPM thickness detectors will have the following characteristics:

1. High speed: Previous vehicle-mount version is working at 10 to 15 mph, which limits the usability of this device. The new version will work at 30 to 60 mph.
2. Fast scanning: The new system will employ an auto-synchronized laser scanning method. This new method with high speed laser scanning makes a highway speed vehicle-mount TPPM thickness measurement faster and more accurate.
3. Improved signal processing method and software interface for the vehicle-mount TPPM thickness measurement. There are three steps in this project. The first step is to improve the speed of the laser system. The second step is to improve performance of the vehicle-mount device for robustness and accuracy. The third step is to conduct field tests and improve software for system.

Research Products
- A high-speed vehicle-mount device that can measure thickness and uniformity of thermoplastic pavement marking on the roadway.
- A user manual for the use of developed vehicle-mount version prototype device in the field.
RMC 5 - Overview
### RMC 5 – New Starts

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5253</td>
<td>D-Region Serviceability Design</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5367</td>
<td>Development of Simple Bridge Deck Details at Expansion Joints</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5498</td>
<td>Methods of Evaluating the Redundancy of Steel Bridges</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-5506</td>
<td>Design of MSE Retaining Walls Placed in Front of a Stable Face</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5530</td>
<td>Predictions of Embankment Settlement Over Soft Soils</td>
<td>8/31/2008</td>
</tr>
</tbody>
</table>

### RMC 5 – Continuing Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Title</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1401</td>
<td>Determination of Fatigue Damage in Cable Stays</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-1774</td>
<td>Effect of Wrapping Chloride Contaminated Structural Concrete with Multiple Layers of Glass Fiber/Composites and Resin</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4124</td>
<td>Methods to Develop Composite Action in Non-Composite Bridge Floor Systems</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4563</td>
<td>Prediction Model for Concrete Behavior</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4588</td>
<td>Effects of Voids in Grouted, Post-Tensioned Concrete Bridge Construction</td>
<td>8/31/2008</td>
</tr>
<tr>
<td>0-4624</td>
<td>Performance and Effects of Punched Holes and Cold Bending on Steel Bridge Fabrication</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4638</td>
<td>Fabricated Plate Tolerances and Design Slenderness Values for Steel Bridges</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-4759</td>
<td>Rational Shear Provisions for AASHTO LRFD Specifications</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4823-CT</td>
<td>Mechanical Anchors for Retrofit/Repair of Bridge Rails</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4825</td>
<td>Corrosion Performance Tests for Reinforcing Steel in Concrete</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-4862</td>
<td>Correlation of Texas Cone Penetrometer Test Values and Shear Strength of Texas Soils</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>Project Number</td>
<td>Title</td>
<td>End Date</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>0-4889</td>
<td>Sulfate Resistance of Concrete Exposed to External Sulfate Attack</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5040</td>
<td>Effects of Thermal Loads on Texas Steel Bridges</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5111</td>
<td>Liquid Nitrogen Effects on Concrete</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5134</td>
<td>Self-Consolidating Concrete for Precast Structural Applications</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5197</td>
<td>Continuing Research on Allowable Design Release Stresses for Prestressed Concrete Beams</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5202</td>
<td>Determination of Field Suction Values in High PI Clays for Various Surface Conditions and Drain Installations</td>
<td>8/31/2006</td>
</tr>
<tr>
<td>0-5207</td>
<td>Effects of Texas Flyash on Air-Entrainment in Concrete</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>0-5218</td>
<td>Extending Service Life of Large or Unusual Structures Affected by Premature Concrete Deterioration</td>
<td>8/31/2007</td>
</tr>
<tr>
<td>9-1521</td>
<td>Lithium Field Implementation Trials - Treating Existing Concrete Exhibiting Distress Due to Alkali-Silica Reactivity</td>
<td>8/31/2006</td>
</tr>
</tbody>
</table>
RMC 5 - New Starts
Abstract
Strut and tie models were introduced in the AASHTO LRFD Specifications in 1994. During the past decade, TxDOT engineers have been studying the new design provisions and evaluating their impact on typical bent-cap construction. A major concern is the discontinuity in nominal shear capacity of bent caps at the transition between strut and tie models (a/d<2) and sectional models (a/d>2). In addition, unusually wide shear cracks have recently been observed in several bent caps that were designed using the AASHTO Standard Specifications. The primary objective of this project is to develop appropriate strength and serviceability design provisions for bent caps and other deep beams. The research includes evaluation of the actual performance of bent caps throughout the state, large-scale tests of representative bent caps, detailed evaluation of the measured experimental data, correlation of observed crack widths with residual capacity, and development of design examples. Research results will be summarized in typical code language and these results will be presented to AASHTO. Revised serviceability design and capacity determination methodologies will be of immediate use to TxDOT bridge engineers.

Research Products
- Recommendations for design code changes to limit diagonal cracking of deep members at service loads will be developed. Recommendations for accurate determination of capacities for large beams with a range of reinforcement rations will also be developed.
- Design Examples: Strut and Tie Method design examples utilizing proposed recommendations that include girders placed on a cantilever cap and on an interior bay of a multi-column cap will be developed.
Abstract
Research conducted under TxDOT Project 0-4418 provided information on the behavior of expansion joint details that has the potential to simplify bridge deck construction, reduce construction costs, and improve worker safety. Full-scale tests of bridge decks demonstrated that a constant thickness cast-in-place deck with additional reinforcement at the edge exhibited essentially the same performance as decks with the IBTS detail that is commonly specified for Texas bridges. The IBTS detail consists of a cast-in-place thickened edge in a deck. The interior portion of the deck is generally constructed using precast, prestressed panels and a cast-in-place topping slab. The cast-in-place edge requires extra formwork and poses higher risks for the workers as well as for the traffic beneath if the roadway remains open to traffic during construction. Because the constant thickness cast-in-place deck detail performed well, an alternative construction procedure was studied in which precast panels were placed adjacent to the expansion joint and the cast-in-place topping slab added. Once again, the performance was excellent and the results indicated that temporary formwork could be replaced with the stay-in-place precast panels. Decks designed using this detail are safer to construct and less costly. However, the test specimens were statically loaded to failure (generally a punching shear failure at the load point) and the performance of the expansion joint edge was not studied under fatigue loading conditions. Because the edge may be subjected to higher loads, especially if there is a bump near or at the edge that causes impact loads, it was recommended that fatigue loads be applied to ensure that the precast panels will perform satisfactorily under the higher stress range expected near the expansion joint and confirm that the interface between the precast panels and the cast-in-place topping slab will not debond under fatigue loads.

Project 0-5367 aims to provide technical information for:
• The performance under fatigue loading of expansion joint edges in decks of bridges with constant thickness decks using precast panels placed up to the edge and overlaid with a topping slab.
• The development of approaches for utilizing innovative panels that can be placed and used as stay-in-place forms at skew edges to eliminate the need for cast-in-place construction at expansion joints in nearly all Texas bridges.

Research Products
• Design recommendations
Abstract

Bridges that are classified as failure critical by AASHTO require more frequent inspections than other types of bridges, resulting in greater costs for their design and operation. These higher costs are justified if the use of such bridges does indeed pose a greater risk to the traveling public in comparison to other bridge types. However, several historical events involving the failure of main load-carrying members in steel bridges have demonstrated the ability of bridges to have significant reserve load carrying capability. For example, the girder failure of the I-79 Bridge at Neville Island in Pittsburgh in 1977 and the Hoan Bridge in Milwaukee in 2000 have shown that severe damage can occur without necessarily resulting in bridge collapse. Consequently, research is needed to characterize and define the different redundancies that can be safely incorporated into the evaluation of failure-critical bridges. With such information, it may be possible to modify inspection procedures and bridge classifications so that costs are dramatically reduced. The project will develop guidelines for modeling a bridge’s behavior after failure of a critical component. The research will include nonlinear structural modeling coupled with laboratory testing to validate analysis predictions. Modeling guidelines will be developed that can be used by TxDOT engineers and their consultants to evaluate the behavior of steel bridges with critical structural components.
Abstract
There is a need for a simple method to bracket the range of potential scour particularly for average size structures including soil types for evaluation or design. TxDOT, in a project with Texas A&M University, developed the SRICOS-EFA method to predict scour depth in any soil and soft rock, and an apparatus, the EFA, to measure the erodibility of soils and soft rocks. The SRICOS-EFA Method is used for both cohesive and cohesionless soils and currently exists at two levels of complexity. The "extended" SRICOSEFA method requires the testing of soil samples from the site in the EFA, the use of a velocity hydrograph, and the use of a computer program. The "simple" SRICOS-EFA method requires EFA testing, a single maximum velocity, and does not require a computer program; it can be done on the back of an envelope. The goal of this project is to further simplify the simple method and obtain a method which bypasses EFA testing all together and relies only on routine soil information. The price to pay for this is likely a loss of precision so that ranges of scour will be the output rather than a precise number. This approach will benefit from the solid background which forms the basis of the SRICOS-EFA methods and keep consistency in the TxDOT methods (all SRICOS methods) at various levels of sophistication where the engineer can choose the method most appropriate for the precision required in the predictions. At the end of the project, TxDOT will have a collection of 3 consistent scour prediction methods aimed at answering different engineering needs: 1. The very simple SRICOS method, 2. The simple SRICOS-EFA method, 3. The extended SRICOS-EFA method. Method 1 will be developed in this project. Methods 2 and 3 already exist.

Research Products
- Simplified Methods for Estimating Scour
Abstract

TxDOT has successfully designed and built Mechanically Stabilized Earth (MSE) walls for a number of years. Recently there have been increased instances where such walls are being placed adjacent to an existing stable fill (e.g., an MSE wall) or cut (e.g., a stabilized slope). In numerous cases the space (width) available for the new wall is less than the width established in current guidelines for stand-alone MSE walls. This has prompted the use of shorter reinforcement and possibly anchoring of the reinforcement of the new wall to the stable face of the existing structure. Also, depending on geometric requirements the new wall may be of the same height as the existing stable face or higher. When the new wall is higher than an existing structure the upper portion of the new wall will not be backed by a stable face and the additional surcharge of fill may impose additional loads on both the existing slope and new wall. Although walls have already been designed and constructed for such applications, design guidelines do not exist, and it is not clear whether the designs are either overly conservative or inadequate. The objective of this research is to develop design guidelines for such composite walls. Although charts and procedures have been developed for estimating the stresses behind MSE walls placed in front of stable faces and with limited space between the wall and stable face, existing procedures assume that the full soil strength and active earth pressures can be developed. None of the procedures have been validated against field data or using deformation analyses. Accordingly, they do not consider the actual deformations and stiffness of the wall system and how they may affect the stress distribution. Some studies indicate that the pressures may be higher while others suggest the pressures may be lower than those behind conventional walls where there is more space between the wall and stable face or natural ground. For the proposed research a series of both finite element stress-deformation analyses and separate limit equilibrium analyses will be performed for candidate wall geometries. We will consider various aspect ratios for the reinforced soil zone as well as relative stiffnesses of the new wall system and existing stable face. Results of these analyses will be compared with results of an extensive series of centrifuge tests that involved reduced scale MSE retaining walls placed in front of a stable face and loaded to failure. This will allow us to "calibrate" and verify the results of the analyses. Once this is completed additional parametric studies will be performed to develop suitable design charts for conditions that are typical of TxDOT projects. Ultimately we will develop design guidelines based on simple limit equilibrium procedures consistent with those currently in use for MSE walls. The design guidelines will most likely be in the form of extensions to the present design procedures for MSE walls to account for the influence of an adjacent stable face with limited space between the existing stable face and new wall. These will also take into account additional surcharge loads imposed by increasing the height above that of the existing adjacent slope of wall.

Research Products

- Design guidelines and recommendations for MSE walls constructed adjacent to a stable face.
Abstract
Estimating the consolidation settlement magnitudes and settlement rates for overconsolidated and normally consolidated soft clays are very important for TxDOT along the Texas Gulf Coast region. Current settlement predictions are based on the consolidation parameters obtained in the laboratory from the "undisturbed" samples collected during the subsurface investigations. It has been observed that the settlements predicted using the conventional methods were very high compared to the measured settlements. Predicted high settlement calls for ground modifications before constructing the embankment, resulting in unnecessary cost for TxDOT. The accuracy of estimated consolidation settlement magnitudes and settlement rates depend on various factors which must be identified and quantified for accurate predictions. In this study, the current procedures used by TxDOT to predict embankment settlements, along with the laboratory test data and limited field data, will be reviewed. The new modified procedures to be used in better predicting settlement magnitudes and settlement rates will be developed. The new procedures will be developed based on the data obtained from field, and laboratory tests.

Research Products
- Suggested field testing procedures for estimating consolidation properties of soft soils.
- Suggested procedures for laboratory consolidation testing of soils.
- Recommended methodology for estimating consolidation settlement magnitudes and settlement rates of soft soils due to embankment/retaining wall construction.
RMC 5
Continuing Projects
Abstract

There are two long-span cable-stayed bridges in Texas: the Veterans Memorial Bridge near Port Arthur and the Fred Hartman Bridge near Baytown. Large amplitude stay cable vibrations have been observed at both bridges numerous times during the past few years. In most cases, these vibrations have occurred in combination with light rain and relatively low winds. The objective of this study is to determine the likelihood that these vibrations have caused fatigue damage to the stay cables. A coordinated experimental and analytical research program will be carried out. Field measurements of cable strains and accelerations will be used to calibrate analytical models of the stay cables. These analyses will be used to determine critical locations of stress, curvature, and rotation along the length of the cable. Fatigue tests of full-size cables will be conducted in the laboratory to determine the relationship between stress amplitude and fatigue damage. The results from both phases of the study will be combined to develop procedures for evaluating the likelihood of actual fatigue damage.

Research Products

- Procedures for estimating the likelihood of fatigue damage at critical sections along the length of the stays in both bridges.
- Procedures for estimating the relationship between stress range, curvature, or rotation and fatigue life of the stay cables.
- Recommendations on the effectiveness of NDT techniques for identifying fatigue damage in stay cables.
Abstract
The project will investigate the efficacy of FRP wrapping to repair chloride-contaminated structural concrete members. A comprehensive accelerated laboratory corrosion test program will be conducted on chloride-contaminated specimens incorporating the most promising of FRP wrapping systems. Variables to be examined include level of chloride contamination, damage and repair of concrete prior to wrapping, black and epoxy-coated reinforcing steel, and wrapping technique. The laboratory program will evaluate the performance of FRP wrapping techniques using both small concrete specimens as well as the performance and long-term stability of the FRP materials under UV exposure, thermal cycling, deformations, and other conditions. A field exposure testing program will also be conducted for long-term performance monitoring. The researchers will assist TxDOT bridge engineers in implementing FRP wrapping techniques in existing structures.

Research Products
- Guidelines for selection and use of wrapping materials
Abstract
A number of older bridges in Texas are constructed with floor systems consisting of a noncomposite concrete slab over steel girders. A potentially economical means of strengthening these floor systems is to connect the existing concrete slab and steel girders to permit the development of composite action. The resulting composite beam can achieve strengths of 50 percent higher than the existing steel girder acting alone. Composite action permits the existing steel girder and concrete to work together in a far more efficient manner than possible in the original non-composite condition. In order to achieve the benefits of composite action, the existing steel girder must be connected to the existing concrete slab so as to permit the transfer of shear forces at the steel-concrete interface. For new bridges, composite action is achieved by welding shear studs to the top of the steel girder prior to casting the concrete slab. In the case of an existing bridge, this approach is not possible, since the slab is already in place. Consequently, in order to take advantage of composite action in existing bridges, economical and practical methods for post-installing shear connectors are needed. The primary objective of this research project is to investigate economical, practical, and structurally effective methods for developing composite action in non-composite bridge floor systems. Methods for post-installing shear connectors will be identified and will be evaluated with respect to structural performance as well as constructability. A number of methods for installing shear connectors will be investigated using a variety of anchor types, configurations, and load transfer mechanisms. Promising methods will be evaluated by laboratory testing of "push-out" type specimens to investigate shear connector behavior and strength, as well as by testing of large scale girders with concrete slabs to investigate overall system performance. Recommendations for design procedures and construction techniques will be developed.

Research Products
- Recommended methods and design procedures for adding composite action to existing non-composite bridge floor systems
Abstract

Numerous examples of corrosion in post-tensioning systems and failures of tendons have been observed in Europe and the United States in recent years. Examples have been cited recently in some of Florida’s major bridges. The cause of corrosion and accelerated deterioration of post-tensioning systems can be traced to several sources, including: incomplete flushing of water prior to the grouting process, incomplete grouting of post-tensioning tendons, excessive bleed water, leaky precast joints, cracking of polyethylene pipe, and poor post-tensioning system details that permit recharge of tendons, to list a few.

The proposed first phase of this project will identify oils or other products that will provide temporary corrosion protection in post-tensioned tendons which have not yet been stressed and grouted during the construction process. This first phase of the research will investigate how these oils affect friction losses during post-tensioning, determine the impact that emulsifiable oils have on bond strength of multi-strand tendons, and examine how flexural capacity is affected by the expected loss in bond strength.

The second phase of the project will identify post-tensioning systems and materials candidates for alternate corrosion-resistant post-tensioning systems, examine physical and mechanical properties of new materials, identify and evaluate potential accelerated corrosion test methods, plan and implement a series of tests to examine the durability of post-tensioning materials and systems, consider the constructability and behavior of post-tensioning systems incorporating corrosion-resistant materials or details identified through durability testing, and develop recommendations for implementation of alternate corrosion-resistant post-tensioning systems.

Research Products

- Specifications/Code Provisions related to expected reductions in friction losses resulting from use of emulsifiable oils and reduced flexural capacities resulting from reductions in bond of post-tensioned tendons
The objectives of this project are: (1) to review the state of the art regarding heat generation in structural concrete; (2) to perform laboratory evaluations on materials typically used in structural concrete, thereby generating data to be integrated into the heat generation model; (3) to develop a user-friendly model (using an Excel interface) to predict the heat distribution, cracking potential, and time to corrosion in structural concrete elements that can be used to select materials and mixtures to minimize thermal gradients and prevent cracking; (4) to calibrate and validate the heat generation model to ensure high levels of accuracy; and, (5) to assist TxDOT in implementing the key research findings and products, and as a result, helping to improve the quality and durability of structural concrete structures in Texas.
Abstract

New provisions for fatigue design in Section 11 of the Standard Specifications for Structural supports for Highway Signs, Luminaires, and Traffic Signals (the Specification) issued in 2001 have made it difficult for Texas and other states to find economical AASHTO-compliant design solutions for cantilevered traffic signal structures. The provisions were developed based on a body of NCHRP research that included limited wind tunnel testing and fatigue testing of traffic signal structures and their connections. This research concluded with major recommendations for further studies to:

• clarify the behavior of such structures in field tests, in particular the equivalent static loading equations developed for wind-induced and truck-induced gusts;
• parameterize the effectiveness of motion-mitigation devices to inhibit oscillations and, hence, cyclic loading that leads to fatigue damage.

The project addresses these two important questions, by conducting both controlled and field studies that will measure loads resulting from two phenomena, galloping and truck-induced gusts. These will be studied for typical cantilever-type traffic signal structures. In addition, reliability analysis will be employed along with suitable analytical models and simulation procedures for both phenomena in order to establish realistic fatigue loads, thus addressing the "load side" of the fatigue design equation, an aspect of this problem that has historically received far less attention than has the resistance side.
Abstract

Post-tensioned bridge systems provide many advantages for designers and constructors. However, recent investigations of post-tensioned concrete bridges and buildings in the UK and US have indicated a link between poor grout and/or voids and observed tendon corrosion. Because corrosion damage to post-tensioned tendons can result in high replacement costs, an evaluation of the corrosion susceptibility and impact of tendon corrosion on the performance of post-tensioned systems is needed. Guidelines are necessary to identify cases when mitigation is required and to determine an appropriate timeline for mitigation so that localized tendon damage, and potential structural failure, can be avoided. The study defines a comprehensive approach to addressing the effect of voids, material parameters, and environmental parameters for post-tensioned concrete bridge construction. The project objectives will be met through nine tasks: (1) Review literature and current state of practice, (2) Review bridge inventory, conduct field inspections, and develop environmental characterization map, (3) Conduct experimental program to evaluate the corrosion performance of post-tensioned tendons, (4) Evaluate damage assessment strategies for void detection, (5) Perform structural assessment and reliability analysis, (6) Conduct validation testing of post-tensioned beams, (7) Implement mitigation strategies for an actual structure, (8) Conduct risk assessment, and (9) writing the final reports.

Research Products

- Inspection and Repair Manual
- Seminar for TxDOT personnel

Research Universities and FY 2006 Budget
Texas Transportation Institute - $223,146

Total Project Budget
$1,030,772
Abstract
An experimental project to compare the fatigue and tensile strength of steel with punched and drilled holes is proposed. The study will examine the influence of type of steel, steel thickness, holes size, punch clearance and wear, and edge distance upon the performance of the plates. The influence of strain aging and temperature are also included. The comprehensive study includes all the major variables in a factorial experiment design which will allow in influence of each variable to be statistically evaluated. The results will provide the necessary information to determine if the use of punched holes can be expanded or if the current limitations need to be stricter. This project will also investigate cold bending of steel plate and the influence it has on material properties and behavior. The cold bending fabrication method can be an inexpensive alternative to either cut or heat curving. Cut curving can result in excessive waste, while heat curving can be time consuming. Cold bending is attractive to fabricators, but in order to permanently bend a plate, plastic deformation must occur, introducing localized regions of high stress and strain, which may result in an unacceptable reduction in ductility and fracture toughness. The objective of this portion of the research effort is to provide fabrication guidelines for cold bending with specific limits on maximum loads, strain, and curvature.
Abstract
The connection between plate tolerances and reasonable b/t ratios for design of steel bridges is an area in need of further investigation. Many Texas engineers currently employ b/t ratios recommended by TxDOT’s Texas Steel Quality Council Preferred Practices throughout the bridge instead of just in compression regions. Adhering to these b/t ratios may have a negative impact on overall bridge economy since the design stress is often not controlling the plate sizes over a large portion of the bridge. Limitations on the slenderness values of plate elements in critical compression regions of bridges are specified to control local buckling. The load displacement response of a plate below the buckling load is directly dependent on the initial imperfection of the plate, and hence fabrication tolerances are also specified in addition to design slenderness limitations. However, there are inconsistencies in tolerances for plates, specified in ASTM A6, and plates in fabricated bridges, specified in the AWS D1.5 Bridge Welding Code and the Texas Standard Specifications. To further complicate the issue, box girder elements are not specifically addressed by AWS D1.5, and appropriate tolerances for box girder components, particularly bottom flange elements, need to be established. In this research study, the impact of fabricated plate tolerances on structural behavior of steel bridges will be investigated and suitable limits for design slenderness values and plate tolerances will be established and subsequently recommended for adoption by the appropriate codes.

Research Products
- Tolerances, based on structural performance and constructability, for elements of steel girder bridges.
- Recommended plate slenderness values for design of steel girder bridges.
- Curved Steel Girder Slenderness Limits
Abstract
Prestressed concrete has become the predominant construction method in highway bridge girders. However, current AASHTO design guidelines for shear are very complicated and inaccurate. Because of their empirical nature, they are also difficult to extrapolate to high-strength concrete. This research will use a rational approach to study the shear behavior of prestressed concrete girders, and to develop design recommendations that can unify prestressed and non-prestressed girders, as well as normal-strength and high-strength concrete. The proposed approach consists of three steps. The first step is to test full-size prestressed panels, in order to establish the effect of prestress on the constitutive laws of concrete and prestressing steel. The second step is to generalize Loov's rational Shear theory for non-prestressed girders, so that it becomes applicable to prestressed girders. This can be achieved by feeding the new constitutive laws of concrete and prestressing steel into the theoretical model and by deriving a "prestress factor" for the "concrete contribution." The new "concrete contribution" should be applicable to high strength concrete. The third step is to evaluate the adequacy of the unified shear theory in predicting the behavior of prestressed concrete girders by testing large, bridge-type, I-girders that fail in various shear modes.
**Abstract**

Repair of damaged bridge railings due to vehicular impacts is a common occurrence. These repairs are often extensive and require considerable time, manpower, and other resources. These repairs also expose workers to hazardous work zone conditions. Often it is desirable to retrofit existing bridge structures with different railing systems. There is a need to develop alternative anchorage systems for select TxDOT Bridge Rails that have acceptable structural performance yet are easily constructed in the field. It is preferable that an alternative anchorage system be used for both repair and retrofit applications. This study will focus on developing alternative rail anchorage systems for the T501 and T203 Bridge Railing Systems. Current strength data on the existing T501R “bolt-through” retrofit design is not well documented. A retrofit design for the T203 does not exist at the time of this writing. This study will obtain documented data on the existing strength characteristics of the T501 and T203 Bridge Railing Systems. This data will be analyzed and used to develop alternate rail anchorage systems for both the T501 and T203 Bridge Rails. Additional alternative repair and retrofit designs could be developed for these railings as well as other TxDOT Bridge Rails as part of this study.

**Research Products**

- Design Recommendations

**Research Universities and FY 2006 Budget**

Center for Transportation Research - $85,903

**Total Project Budget**

$294,803
Abstract
Many different test procedures for characterizing the corrosion performance of steel embedded in concrete are reported throughout the literature. Some of these procedures evaluate the probability of active corrosion, some evaluate the corrosion rate, and others evaluate the critical chloride threshold of the steel reinforcement embedded in the cementitious materials. The reliability, repeatability, complexity, time requirements, and costs of the different test procedures have not been thoroughly evaluated. Thus, the objective of this program is to evaluate several test methodologies and provide recommendations to TxDOT on the time and cost requirements, accuracy, repeatability, and reliability of the different test methods. Corrosion tests in cementitious materials will include the CCIA, ACT (developed at Texas A&M University), mini macrocell (developed at the University of Kansas), Southern Exposure, and ASTM G109 test procedures. Solution testing and chloride migration testing are also proposed to complement the corrosion testing in cementitious materials. The objective of this test program is to recommend a screening test or suite of screening tests that can cost-effectively evaluate the influence of different materials on the corrosion performance of steel embedded in cementitious materials over short durations.
Abstract
In Texas, Texas Cone Penetrometer (TCP) tests are conducted during foundation exploration. Since the tests are routinely done and required during foundation exploration for TxDOT projects, a large amount of data from these tests can be made available. Correlations based on the test values could be very useful to engineers to determine the shear strength of the soil. In urgent situations, such as slope failures, the TCP may then provide a rapid way to determine soil shear strength. Limited research was done in 1974 and 1977 to correlate the TCP values as shear strength parameter, especially for soil conditions in the Upper Gulf Coast region. Research must be done on a larger number of soil samples in various subsurface conditions, such as the presence of a high groundwater table, and in stratified soil formations. This research will develop equations, which can be used by engineers with a high level of confidence to predict the shear strength parameters for various types of soils found in Texas. Based on the data available and proposed field and laboratory tests, correlations will be developed between TCP values and shear strength parameters of soils in Texas.

Research Products
- Equations for predicting the shear strength based on TCP value for various Texas soils

Research Universities and FY 2006 Budget
- Lamar University - $12,186
- University Of Houston - $54,822
- University of Texas at Arlington - $20,000

Total Project Budget
$175,000
Abstract
Sulfate attack is a fairly complex process in that it can result in either physical attack or chemical attack on concrete, and the sources of sulfates can either be internal to the concrete (e.g., DEF) or from external sources, such as groundwater, soils, and agricultural run-off. Texas is a state with relatively high sulfate concentrations (in soil and groundwater) and has long been aware of the potential for sulfate attack. Specifications have been followed over the years that have helped to protect the state from significant external sulfate attack. However, one concern is that the current and upcoming specifications dealing with sulfate attack do not allow for the use of Class C fly ash due to concerns over its poor sulfate resistance (when used by itself without another supplementary cementing material (SCM)). Research by Dr. Michael Thomas has shown that silica fume can be used in small doses to enable the use of Class C fly ash in sulfate-rich environments. Similar research is needed on Texas Class C fly ashes, especially those found in areas without an affordable Class F fly ash source.

Research Products
- Guidelines for using Class C Fly Ash to Control External Sulfate Attack
- Specifications for sulfate-resistant concrete.
- Recommended test methods for assessing sulfate resistance.

Research Universities and FY 2006 Budget
Center for Transportation Research - $137,750

Total Project Budget
$419,500
Abstract
The effects of thermal loads on Texas's steel bridges, as well as the appropriateness of the procedures in AASHTO specifications for including thermal effects, are unclear. These uncertainties impact not only the design of the steel components of these bridges, but also the bearing design. The directional guides on the bearings of the bridges are laid out to attempt to permit unrestricted movement under uniform thermal loads, however, the actual thermal loading experienced by these bridges is not uniform. TxDOT has sponsored three projects which involved field monitoring of steel trapezoidal box girder bridges, and in each of these studies significant stresses were developed under regular daily thermal cycles. Thermal stresses on the order of ±5 ksi were not uncommon in these daily cycles. None of these studies, however, measured the thermal stresses that develop over annual thermal cycles, nor the movement, or lack thereof, occurring at the bearings of these girders during these annual thermal cycles.

A preliminary assessment of the impact of thermal loads conducted in Project 0-4307 Trapezoidal Box Girders: State of the Art has shown the thermal problem to be very complicated and worthy of a full investigation. There are several factors that increase the complexity of the problem, including the fact that the thermal loading is bridge specific, and thus varies with the particular geometry and orientation of the bridge. Furthermore, the use of two materials, steel girders with a concrete deck, with different thermal conductivity properties also complicates the problem. It is clear from observation of existing bridges that guidance is needed for orientation of restraining devices and sizing of expansion joints. Some options that would yield large costs savings, like the potential for tangential orientation of lateral guides and reduced expansion joint capacity, require a thermal study to be properly addressed. Recent practice in laying out bearings on the typical two-girder box system includes the use of lateral guides on one girder, while the second girder is supported on multi-directional bearings. This practice seems advisable based on thermal effects, however, the Houston Chapter of the Associated General Contractors of America has requested that guides be placed on both girders to increase stability during erection. The impact of guiding both girders on thermal stress development needs to be investigated. The proposed project will examine the effects of thermal loads on the steel superstructure and will investigate alternate bearing layouts that permit optimal performance under expected thermal loads while maintaining adequate constructability.

Research Products
• Suggested layout for bearing guides on steel bridges based upon thermal performance
• Recommended methodology for accounting for thermal loads on steel bridges.
Abstract
Dosing fresh concrete with liquid nitrogen is an economical means of lowering the initial temperature of concrete at time of placement. The objectives of this research project are to investigate: a.) the safety implications of liquid nitrogen applications; b.) the effects of liquid nitrogen on mixing equipment; c.) the effects of liquid nitrogen on cement hydration and microstructural development; and d.) the effects of liquid nitrogen on concrete properties including fresh properties, strength, dimensional stability, and durability. Data obtained will be analyzed in order to recommend optimal liquid nitrogen delivery devices and methods with regard to human and equipment safety and minimal negative effects on concrete properties.

Project - 0-5111
Liquid Nitrogen Effects on Concrete

Start Date - 09/01/2004
End Date - 08/31/2006

Program Coordinator
Maribel Chavez, FTW

Project Director
Ralph Browne, BRG

Project Advisors
Andy Naranjo, CST
Charles Chance, AUS
David Head, ELP
Elizabeth (Lisa) Lukefahr, CST
Joseph Roche, CST
Lloyd Wolf, BRG
Richard Willammee, FTW
Tracey Friggle, DAL

Research Supervisor
Maria Juenger, CTR

Research Products
• Guidelines for plant and site dosing of liquid nitrogen.
• Recommend safety procedures, including video footage.
• Recommend specifications modification due to liquid nitrogen effects on concrete properties.

Research Universities and FY 2006 Budget
Center for Transportation Research - $119,000

Total Project Budget
$237,000
Abstract
Self-consolidating concrete (SCC) is a relatively new technology that has potential to lower construction cost, improve safety at work sites, and increase construction productivity. As with most new technologies, research is needed to determine pertinent characteristics such that safe, fast, reliable, repeatable, and durable products can be made with this material. This research will investigate both the early age (fresh and transitional) and later age (hardened) characteristics of SCC using materials available in Texas. Special attention will be focused on requirements for precast, prestressed concrete products and how SCC will impact the constructability and performance of these elements. From the testing and observations observed from the research, the researchers will develop a manual for the inspection of fresh SCC and will identify needed changes to specifications and design codes for the Texas Department of Transportation.

Research Products
- Manual for TxDOT inspectors to evaluate SCC mixtures
- Suggestions for TxDOT specification changes to utilize SCC
- Suggestions for any design code modifications that need to be implemented as a result of using SCC
Abstract
The research results of TxDOT Project 4086 provide a preliminary basis for suggesting that raising the allowable stress factors for release may be an alternative. However, further testing of the specimens is necessary to determine the effects of having exposed the relatively "green" concrete to elevated compressive stresses. Hence, testing of the Project 4086 beams to evaluate their complete load deformation behavior, cracking point, elastic and cracked section properties, and fatigue behavior will be performed. In addition, tests on full-scale pretensioned girders will be conducted prior to adopting new stress limits at release. In these tests, typical TxDOT beams subjected to the "new allowable compressive stresses" will be manufactured and monitored. TxDOT has seen a recent increase in the amount and severity of cracking in the ends of short-span Type IV beams. In order to experimentally evaluate the top and bottom fiber strains and stresses, the research team will build and test full-scale models of the end regions of Type IV girders with varying strand eccentricities.
Abstract

Moisture infiltration into highway embankments constructed by TxDOT of high PI clays results in the decrease of soil suction and often leads to costly shallow 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 and shear strength of high PI Texas clays collected from embankments of different ages. The field and laboratory results will be used to calibrate simple models for strength vs. time in compacted clay and to assess the conditions for surficial slope instability. Achieving this objective will allow the research team to recommend relevant suction and shear strength information, to assess the influence of critical precipitation events, and to provide guidance on stabilization measures including surface treatments and drain installation. Accordingly, specific activities to be accomplished through research include: (i) compiling a database of information related to compacted clay embankment performance; (ii) evaluating several embankments with different post-construction times in the vicinity of TxDOT projects that have been prone to recurrent surficial stability; (iii) conducting relevant laboratory tests on embankment high PI clays; (iv) refining models to account for rainwater infiltration and preferential flow through cracks; (v) calibrating existing time-dependent models for evaluation of shear strength using collected field and laboratory data, and (v) providing recommended suction-moisture content information and guidance into the use of surface treatments and drainage installation.
Abstract
The use of hybrid (MSE/soil nail) retaining wall construction can, in certain situations, result in greater economy and efficiency of construction. The projected configuration consists of an excavation to emplace the soil nails, with the MSE wall placed on top and backfilled. Currently, the design approach that has been taken is to design both the MSE and soil nail wall to the full projected wall height. This is clearly not an economical approach; nor does it address the specific force-transfer mechanism inherent in the hybrid wall. The salient issues involved in developing design guidelines for hybrid walls are the following:
1. Force transfer between the bottom of the MSE wall and the top of the soil nail wall
2. Deflection control in the hybrid wall
3. Global stability of the hybrid wall
4. Failure planes
5. Effect of construction sequence
The proposed research will produce a set of design guidelines for hybrid walls, with examples. Construction guidelines will also be formulated.
Abstract
Because of the mandatory introduction of low-NOx burners in coal-burning power plants, the nature of some Class F fly ashes has changed, and not for the better when it comes to air entrainment. The change in burning conditions has resulted in a relatively modest increase in carbon content (as measured by loss-on-ignition or LOI), but a disproportionately higher increase in the surface area of the carbon produced. It is this increase in surface area that directly increases the absorption capacity of the carbon, strongly affecting the absorption of air-entraining agents (AEAs).

Significantly higher air-entraining agent (AEA) dosages were needed in the past year to entrain target air content. The changes in fly ash composition or structure from load to load were also a concern, with producers having difficulty controlling air. This proposed research is intended to address the technical effects and practical implications of these fly ashes on air-entrained concrete in Texas. The research outlined in this proposal addresses the above fly ash-AEA issue and also will address other important air-related issues, such as reported discrepancies between fresh and hardened air contents, and clustering of air bubbles around aggregates. Given the importance of fly ash and air entrainment in Texas, a comprehensive research plan is outlined to try to address air-related issues now before they get any worse.

Research Products
- Recommended test methods for assessing carbon in fly ash and effects on air entrainment.
- Recommended test methods to estimate air-void system using fresh concrete.
- Guidelines for managing air content when using fly ash.
- Guidelines for air content tolerances, rejection criteria, and mitigation techniques.
Abstract
This research is designed to build on the success of TxDOT Project 0-4085 and related projects underway at the Concrete Durability Center (CDC) at UT-Austin and to extend the expertise and knowledge to field structures in Texas. This project will be multi-faceted and will include several key aspects of implementing technology to ensure long-term durability in new structures and to prolong the life of existing structures exhibiting distress due to alkali-silica reaction and delayed ettringite formation. Included in this research are: (1) evaluation, mitigation, and monitoring of sections of the San Antonio Y; (2) laboratory and exposure site evaluations of DEF to determine resultant stresses and requisite levels of restraint to control damage; (3) assessment of structures for ASR/DEF deterioration; (4) treatment and monitoring of ASR/DEF affected structures with innovative techniques.

Program Coordinator
Keith Ramsey, BRG

Project Director
Dingyi Yang, BRG

Project Advisors
Amy Eskridge, BRG
Brian Merrill, BRG
Clara Carbajal, SAT
Jennifer Moore, CST
John Vogel, HOU
Les Jarosz, HOU
Lloyd Chance, AUS

Research Supervisor
Kevin Folliard, CTR

Research Universities and FY 2006 Budget
Center for Transportation Research - $300,000

Total Project Budget
$800,000

Research Products
Abstract
This project will determine the effectiveness of treatments believed to arrest the deterioration of Alkali Silica Reactivity (ASR) expansion in existing deteriorated concrete. The following four mitigation methods will be considered:

1) A single application of lithium nitrate solution applied with the vacuum impregnation method;
2) A moisture blocking surface treatment using a penetrating sealer of silane or siloxane, and then caulking all open cracks. One half the treated area will then be painted.
3) A combination of the above two methods, but without any paint; and
4) A spray on application of the lithium nitrate solution applied at four separate times.

A fifth beam will be untreated and used as the control.

TxDOT possesses nine unused prestressed box beams that are excellent candidates for this research. These beams are already showing ASR cracking, and are still sitting unused at the prestressing plant in Corpus Christi, Texas. TxDOT rejected these beams because long horizontal cracks formed in the webs of the box beams. Petrographic analysis shows ASR gel and expansion in this concrete.

UTEP will work very closely with the TxDOT staff to conduct the necessary nondestructive field and lab testing throughout the life of this project.