



# Research Digest

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## *Item 1*

### **Bending Fatigue Response of Grouted Stay Cables**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)  
CTR 1401-1 • 2008*

Both the Fred Hartman Bridge and the Veterans Memorial Bridge have experienced large-amplitude vibrations of the stay cables. A major concern resulting from these vibrations is the possibility of fatigue damage to the parallel, seven-wire, prestressing strand in the grouted stay cables – and the overall safety of the bridges.

An experimental investigation was conducted to determine the susceptibility of grouted stay cables to fatigue damage. Two series of experiments were conducted: twelve stay-cable specimens were subjected to bending fatigue loads in the first series and three small-scale specimens were subjected to bending fatigue loads in the second series.

The test results indicate that fatigue damage is expected to be concentrated in the regions of highest bending stress: the ends of the stays and locations where a damper or restrainer induces local bending in the stay. The risk of fatigue damage was considered to be low at the tension ring, along the free length of the stay, and in the vicinity of unintentionally crossed strands. The acoustic monitoring systems installed on the Fred Hartman Bridge and the Veterans Memorial Bridge provided a reliable means of detecting wire breaks in the laboratory specimens. However, the actual location of a wire break may be 2 to 3 ft from the location identified by the acoustic sensors. Transverse stiffness and natural frequencies of the test specimens were not sufficiently sensitive to detect the accumulation of fatigue damage.

Accumulation of fatigue damage is a slow process, and many wire fractures can be tolerated before the strength or stiffness of the grouted stay cable is compromised. A threshold number of wire breaks at a single location (10% of the total number of wires in the stay) was established before corrective action is recommended for existing stay cables.

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## *Item 2*

### **Prediction Model for Concrete Behavior – Final Report**

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

*CTR 4563-1 • 2008*

This report summarizes work performed under Texas Department of Transportation (TxDOT) Project 4563, Prediction Model for Concrete Behavior. The main product developed under this project is a software program, named Concrete Works, which gives laboratory technicians, engineers, and contractors a tool that combines concrete design, analysis, and performance prediction to improve and optimize the performance of concrete structures.

A unique feature of the testing performed is the use of rigid cracking frames. This test was developed in Germany, and measures the cracking sensitivity of a restrained dog-bone-shaped concrete specimen from the time of concrete placement. Temperature-controlled formwork is used to cure the specimen to match field conditions of mass concrete members. These frames are designed to allow fresh concrete to be cast into their formwork, which enable the study of very early-age behavior of concrete mixtures. More than 70 tests have been completed to date and these results were used to characterize the very early-age creep behavior and risk of cracking of various concretes. Mixture-specific head of hydration values are used to accurately model the effect of various cementitious materials on the in-place concrete temperature distribution. The model has been calibrated with over 33,000 hours of temperature data collected from field sites. The software provides detailed results to check compliance with specification to control thermal cracking, alkali silica reaction, delayed ettringite formation, and service-life expectancy.

This report concludes with a section aimed at implementing ConcreteWorks, with emphasis on how best to use, specify, and check compliance with mass concrete design guidelines.

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[http://www.utexas.edu/research/ctr/pdf\\_reports/0\\_4563\\_1.pdf](http://www.utexas.edu/research/ctr/pdf_reports/0_4563_1.pdf)



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## **Item 3**

### **Evaluation of Bonded Concrete Overlay on IH 610 in Houston, Texas**

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

CTR 4893-3 • 2008

Bonded concrete overlays could provide cost-effective rehabilitation methods for structurally deficient Portland cement concrete (PCC) pavements. Four-inch bonded concrete overlay (BCO) placed in 1986 on Houston's IH 610 North has provided quite satisfactory performance for more than 20 years. Ten test sections were placed as a part of the BCO project during the construction, and after 20 years, they provide invaluable information on the long-term performance of BCO. The variables included in the test sections are reinforcement, coarse aggregate type, and existing pavement condition. The overall performance of 4-in. BCO has been excellent, even though there were a few patches made to address partial depth punchouts. Four-inch BCO over 8-in. continuously reinforced concrete pavement (CRCP) reduced deflections by about one-third, which is good evidence for BCO's ability to enhance the structural capacity of under-designed PCC pavements. Between the two reinforcement types used, welded wire fabric and steel fibers, welded wire fabric provided better performance. It appears that welded wire fabric provided more effective restraint on concrete volume change potential, thus improving bonds between BCO and existing concrete. Two coarse aggregate types were used in the test sections: siliceous river gravel (SRG) and limestone (LS). For the comparable condition, LS provided better performance than SRG. This finding is consistent with the performance in new CRCP, where more spalling and mid-depth horizontal cracking problems occur in sections with SRG. The condition of existing pavement, at least as evaluated with the method adopted in this study, does not appear to have substantial effects on the performance of BCOs. Delaminations and resulting partial depth punchouts were the primary structural distresses. Delaminations were along longitudinal warping joints, as well as under the wheel paths. Those along the longitudinal warping joints appear to be due to environmental loading, while those under the wheel paths were due to wheel load stresses. Full saw cuts through BCO at longitudinal warping joints will minimize delaminations.

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[http://www.utexas.edu/research/ctr/pdf\\_reports/0\\_4893\\_3.pdf](http://www.utexas.edu/research/ctr/pdf_reports/0_4893_3.pdf)

## **Item 4**

### **Inspection Manual for Self-Consolidating Concrete in Precast Members**

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

CTR 5134-P1 • 2007

This manual discusses quality control and testing procedures for SCC used in precast elements. It is intended for use by field inspectors responsible for pre-qualifying mixtures and assuring concrete quality. The information presented is of a general nature and may not be appropriate for all projects. The manual is written on the assumption that the reader already has basic background knowledge of general concrete material properties and construction practices.

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[http://www.utexas.edu/research/ctr/pdf\\_reports/0\\_5134\\_P1.pdf](http://www.utexas.edu/research/ctr/pdf_reports/0_5134_P1.pdf)



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## ***Item 5***

### **Effects of Supplementary Cementing Materials on the Setting Time and Early Strength of Concrete**

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

*CTR 5550-1 • 2008*

The substitution of a portion of cement in concrete with supplementary cementing materials (SCM) frequently results in delayed setting and low early strength. When SCM-containing concrete is placed during cold weather and/or contains certain chemical admixtures, these problems can intensify and can seriously impact the performance of a pavement. This project investigated the setting time, early strength gain, maturity, bleeding, and plastic shrinkage cracking of several concrete pavement mixtures containing SCM under different temperature conditions (mimicking summer, spring, and winter weather). The data were used to develop guidelines for identifying slow-setting mixtures and preventing their use in pavements.

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## ***Item 6***

### **Loss-Rate Functions for Selected Texas Watersheds**

*TEXAS TECH UNIVERSITY (TECHMRT)*

*TechMRT 4193-6 • 2007*

The purpose of this report is to present a set of results from research into loss-rates functions applicable to selected Texas watersheds. The results reported herein comprise the culmination of a set of research components for application of the unit hydrograph method for development of drainage design discharges for Texas transportation projects. A number of loss-rate methods were explored by the research teams represented by members from the U.S. Geological Survey, Texas Tech University, Lamar University, and University of Houston. A variety of approaches are documented in the report, although it is left to the analyst to determine the most appropriate approach for a particular design problem.

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<http://www.techmrt.ttu.edu/Reports/Complete%20Reports/0-4193-6.pdf>



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## ***Item 7***

### **Evaluation of Stabilization of Sulfate Soils in Texas**

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

*TTI 4240-01-1 • 2008*

This implementation project was developed to provide technical support to the Texas Department of Transportation (TXDOT) in developing subgrade soil mixture designs in high sulfate soils and to monitor the performance of projects constructed following the guidelines established in Project 4240. Secondly, the researchers were to assess equipment needs of the TXDOT districts, train laboratory personnel in mix design procedures in high sulfate soils, and provide educational materials for TXDOT to train additional personnel.

Mix designs of high sulfate soils for two projects, in the Austin and Laredo Districts, are reported as technical support to districts. The construction and subsequent reevaluation of the project in Eagle Pass is reported to give TXDOT a record of the construction process used in the high sulfate soil on the Second Street project and shows how the project has performed since construction. Evaluation of the 3-D swell procedure shows the test to be repeatable if the density and water source are tightly controlled. A review of the equipment needed for adequate testing of the high sulfate subgrade soils showed that all required equipment can be obtained at minimal cost to TXDOT.

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

<http://tti.tamu.edu/documents/5-4240-01-1.pdf>

## ***Item 8***

### **Implementation of Traffic Responsive Control on TXDOT Closed-Loop Systems**

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

*TTI 4421-01-2 • 2007*

TXDOT research project 0-4421 “A Simplified Approach for Selecting Optimal Traffic Responsive Control Parameters” developed procedures and guidelines for setting up and operating coordinated systems with the traffic responsive plan selection (TRPS) mode. This project implemented the TRPS mode at four locations in Texas using customized versions of the guidelines developed in research project 0-4421. Customization of the guidelines was necessary to account for the differences in certain site characteristics (e.g., available system detectors) between the implementation sites and the general site for which the original guidelines were developed. Locations were selected to represent a range of traffic conditions, arterial and detector configurations, and the two common controller types (Eagle and Naztec) used by TXDOT. The performance of the TRPS mode was evaluated by a comparison of average instantaneous and link speeds and delays determined before and after the implementation of the traffic responsive control. The before-after analyses indicated that the performance of the TRPS mode was in most cases better or at least as good as the existing systems. A step-by-step field manual to guide field technicians through the process of configuring their controllers to run a TRPS control was also developed and delivered to TXDOT to facilitate the implementation of the TRPS guidelines.

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## ***Item 9***

### **Operator's Manual for FlexPrep Twin Blade Saw**

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

TTI 4467-01-P2 • 2008

The FlexPrep Twin Blade Saw is a laboratory cutting machine used for sawing asphaltic materials into lab specimens for evaluating flexible pavement overlays in the Overlay Tester.

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

<http://tti.tamu.edu/documents/5-4467-01-P2.pdf>

## ***Item 10***

### **PAVECHECK: Updated User's Manual**

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

TTI 4495-01-P1 • 2008

The PAVECHECK data integration and analysis system was developed to merge Falling Weight Deflectometer (FWD) and Ground Penetrating Radar (GPR) data together with digital video images of surface conditions. In project 4495, the earlier system has continued to be expanded with new capabilities. This report provides an updated user's manual for the new program. It is accompanied by a CD that contains an executable program to load the software, along with two test data sets. One data set includes a folder called US77 which contains files of GPR and video images. These data is the typical raw data collected in the field. These files are used to demonstrate how data can be loaded and viewed within PAVECHECK. A second data set named ANNEX is also loaded. This complete data set includes FWD and photos of pavement cores. This data set is used to demonstrate the full capabilities of PAVECHECK.

This system has tremendous potential to assist Texas Department of Transportation (TxDOT) engineers with future forensic and pavement rehabilitation studies. The PAVECHECK framework can also assist in future pavement layer data base efforts and in documenting and evaluating the performance of research test sections.

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## ***Item 11***

### **Underground Stormwater Quality Detention BMP for Sediment Trapping in Ultra-Urban Environments: Final Results and Design Guidelines**

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

TTI 4611-2 • 2008

Permanent stormwater quality structures in developed urban areas require the use of smaller footprint or underground structures. This project investigated if an underground treatment structure made from off-the-shelf precast concrete sections would exhibit the required sediment removal efficiency and involve minimum maintenance. The project consisted of a literature review of small footprint and underground stormwater treatment devices, their cost, performance, and maintenance considerations; and a physical model study to test the principles to be employed and construction of a full-scale prototype for proving the concepts. Research results of conceptual models, physical models and part of the prototype are documented in the first project report entitled "The Development of Nonproprietary Underground Stormwater Quality Structures, Report Number FHWA/TX-07/0-4611-1." These results demonstrate that extended detention can be used to remove suspended solids from stormwater. It also shows that maintenance will be needed to sustain the overall level of performance (in terms of sediment removal). While the efficiency of the structure is around 75 percent removal, approximately 17 percent of the solids discharged can be attributed to resuspension. This report documents experiments conducted on the prototype in an attempt to optimize sediment removal efficiency by reducing sediment resuspension. Design and maintenance guidelines are included in this report. In summary, several refinements show promise in significantly reducing the resuspension loading, which could increase the overall efficiency to over 80 percent with maintenance intervals in excess of twelve months.

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## ***Item 12***

### **Evaluation of Traffic Control Devices: Fourth-Year Activities**

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

TTI 4701-4 • 2008

This project was established to provide a means of conducting limited scope evaluations of numerous traffic control device issues. During the fourth year of the project, researchers completed assessments of five issues: developing an automated process for identifying the start and end of no-passing zones, developing guidelines for the use of pedestrian countdown signals, evaluating the performance of lead-free yellow thermoplastic pavement markings, developing improved guidelines for accessibility issues associated with traffic signalization, and continuing development of the Work Zone Impacts Handbook. The automated no-passing zone activity developed a prototype method of using Global Positioning System (GPS) coordinates to identify the start and end of no-passing zones based on vertical alignment. The activity on pedestrian countdown signals synthesized available information to develop some initial guidelines. The signal accessibility and work zone impacts' activities are producing separate documents that address those issues.

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## ***Item 13***

### **Flexible Base Ride Specifications Development and Evaluations**

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

*TTI 4760-1 • 2008*

The Texas Department of Transportation (TxDOT) is implementing a ride specification that uses profile data collected with inertial profilers for acceptance testing of the finished surface. The ride specification, Item 585, is applicable for either hot-mix asphalt or Portland cement concrete pavements and uses the international roughness index computed from profile measurements to quantify the level of ride quality achieved from construction. Prior to this project, TxDOT did not have a standard ride specification for surface treatments over flexible base courses. Since this pavement type comprises a significant percentage of the state highway network, improving the ride quality of surface treatments is of concern to TxDOT engineers responsible for achieving ride quality standards within their districts. To this end, a standard ride specification was necessary to assure (among other factors) that surface treatments are built with acceptable levels of ride quality. This report documents the work performed to establish applicable criteria for a flexible base ride specification. Through a cooperative effort with TxDOT engineers, researchers evaluated proposed criteria using ride data collected from district projects and investigated the effect of texture on ride quality measurements. Based on the analyses of data collected from laboratory and field tests, researchers found that the requirements given in the flexible base ride specification are appropriate to use for acceptance testing of the ride quality of flexible base on surface treatment projects. Applicable recommendations for implementing the specification are provided in the report.

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## ***Item 14***

### **Guidelines for Hurricane Evacuation Signing and Markings**

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

*TTI 4962-P1 • 2007*

Based on focus group input and surveys of motorists who have recent hurricane evacuation experience, researchers developed guidelines for various hurricane evacuation signs and markings, including route signs, contraflow signs, emergency shoulder lane signs and pavement marking, etc.

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## **Item 15**

### **Feasibility Study for Development of Marine Exposure Site: Technical Report**

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

TTI 5266-1 • 2008

Durability is a serious issue for managers of the U.S. transportation infrastructure. Work remains to be done to improve the service life, life-cycle durability, and both direct and indirect life-cycle cost of reinforced concrete, steel, and other structural materials in all environments throughout the state of Texas. For this project, researchers performed a feasibility study for the development of a marine exposure test site on the Texas gulf coast. The goals of the site are to increase the service life, reduce the capital and maintenance costs, and improve the quality, performance, and safety of transportation infrastructure in Texas through real-exposure research, experimentation, and testing of construction materials and processes.

A literature survey reviews economic studies of durability problems and associated costs, including the costs nationwide and in Texas of deterioration, degradation, and corrosion, and the tangible benefits of improved durability. The project researchers visited and evaluated existing exposure test sites in the U.S. to identify site requirements and the critical success factors for a Texas marine exposure test site. A quantitative cost-benefit analysis was performed considering costs and future benefits in the short-term and long-term. The results demonstrate that the development of a Texas marine test site would be economically feasible and cost-beneficial to Texas.

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## **Item 16**

### **Synthesis of New Methods of Sustainable Roadside Landscapes**

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

TTI 5330-1 • 2007

Several Texas Department of Transportation (TxDOT) 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 the soil's ability to absorb runoff diminishes. TxDOT needs creative alternatives that can help soil retain moisture and recycle nutrients to reduce the energy expended in the maintenance of right-of-way landscape development. Techniques that utilize the environmental processes found in natural, self-sustaining, and self-sufficient plant communities have been clearly demonstrated to minimize and restore development impacts on soil, reduce peak storm flows, and increase infiltration. These techniques include major soil modifications as part of large-scale highway plantings. This project identifies many of the common non-chemical soil amendments and additives that can be used to create an environment that simulates a naturally occurring sustainable system found in undisturbed landscapes. Alternative management practices used by the public and private sectors were investigated for possible application to urban roadside landscapes for TxDOT and included cost and benefit evaluations, and the analysis of traditional and more sustainable landscaping comparisons of maintenance, water use, erosion control, and pollutant runoff mitigation. As these sustainable landscape development methods evolve, improved maintenance cost savings and public acceptance is anticipated.

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## ***Item 17***

### **Preliminary Results of Repeatability and Sensitivity Study on Overlay Tester For Crack Sealants**

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

*TTI 5457-1 • 2007*

This brief summary report documents the main findings from the work done in the last fiscal year. This summary report is composed of three major components: 1) Overlay Tester for crack sealants and associated draft test protocol, 2) repeatability of Overlay Tester for crack sealant, and 3) sensitivity of Overlay Tester for crack sealant. Finally, this report discusses the work recommended by the Pavement Monitoring Committee on October 11, 2006.

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## ***Item 18***

### **Guidebook for Mobility Monitoring In Small to Medium-Sized Communities**

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

*TTI 5571-P1 • 2008*

Transportation professionals in growing small to medium-sized communities (SMSCs) struggle with congestion issues. SMSCs are defined as communities with a population less than 200,000. Congestion in these communities is often highest along state or U.S. highways that also serve significant amounts of local travel. According to TTI's 2007 Urban Mobility Report (1), there were 355 million person-hours of delay in 306 SMSCs in the United States. This equates to \$6 billion in the cost of time and fuel. In Texas alone, there were 12 million person-hours of delay, equating to \$212 million in the cost of time and fuel in 23 SMSCs.

While there are extensive resources and literature dedicated to measuring, monitoring, and improving large urban area congestion, there is a need for guidance for SMSCs to better understand and alleviate congestion before the problems escalate. Potential solutions and performance-measure targets are much different for small communities than those identified in the literature for urban areas.

The primary objective of TxDOT research from which this guidebook was generated was to develop and test a framework for mobility monitoring in small to medium-sized communities (2,3). This guidebook provides a user-friendly step-by-step process for public- and private-sector transportation professionals to implement a mobility monitoring program in their communities. A companion document located in a pocket at the back of this guidebook serves as a reference for nontechnical audiences. This guidebook, and the companion documents produced by this research effort, will be useful for state DOT staff in SMSCs as well as state DOT partnering agencies, including metropolitan planning organizations (MPOs), municipalities, and counties.

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## **Item 19**

**Creating Partnerships with Local Communities to Manage and Preserve Corridors: Technical Report**  
*TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)*  
*TTI 5606-1 • 2008*

There is a serious need in Texas for better integration of land use and transportation planning, and better coordination of land use and transportation decision making. Coordinated local-state partnerships in corridor management and preservation would go a long way toward addressing this disconnect and lack of integration. In light of state's ever-increasing growth and land values, it is critical for TxDOT, like many other state DOTs, to work with communities to ensure that existing and future on-system corridors are managed and/or preserved as part of long-range comprehensive planning efforts and as development occurs.

The objective of the research is to develop methods and guidelines where corridor management and preservation can be accomplished through coordinated application of local and TxDOT regulations. The research will assess the role of locally adopted transportation plans, regional transportation authorities, and MPOs in corridor management and preservation. It will detail regulatory components, zoning overlay districts, current practices, and case studies in Texas and throughout the United States for these activities. The research will review methods and tools for acquiring and preserving right-of-way in the context of expediting the environmental clearance process and review how corridors are prioritized, designated, and adopted for management or preservation.

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## **Item 20**

**Guidelines for Routine Maintenance of Concrete Pavement**  
*TEXAS A&M UNIVERSITY. TEXAS TRANSPORTATION INSTITUTE (TTI)*  
*TTI 5821-1 • 2008*

Concrete pavement has shown great performance in urban area and interstate highway settings for many years because of its low maintenance requirements and capability for long service life. However, rapidly increasing heavy traffic accelerates pavement deterioration and increases the need for more maintenance than in the past. If proper maintenance is not employed at low levels of deterioration, in a timely manner, acute degradation of pavement serviceability will occur and major repair costs may be needed.

This report discusses the visual identification of various distress types and introduces evaluation techniques using nondestructive testing (NDT), which are key to determining proper routine maintenance activities. According to the areas selected from the simplified checklist of visual distress types, falling weight deflectometer (FWD) for structural condition evaluation, ground penetration radar (GPR) for detecting voids below the slab and the presence of trapped water, and dynamic cone penetrometer (DCP) for estimating the in situ strength of base and subgrade soils are used to provide current information on pavement condition for selection of needed repair methods using a simple, systematic decision process. Key routine maintenance activities are categorized into five levels: performance monitoring, preservative, functional concrete pavement repair (CPR), structural CPR, and remove and replace. During field investigations, poorly performing areas were identified and possible fixes determined as a means of guideline development.

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## *Item 21*

### **Management of Hazardous Materials Transportation: Literature Summary**

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

*TTI 5929-P2 • 2008*

This product provides a list of documents, including full bibliographical information and a summary of each document, reviewed in Project 0-5929 for the Texas Department of Transportation (TxDOT). The project's goal was to examine the quantities, origins, and destinations of hazardous materials flows in Texas and the roles of stakeholders; provide guiding principles on effective management of hazardous materials movements; and investigate the hazmat route relocation potential of the Trans Texas Corridor and other rail routes.

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## *Item 22*

### **Potential for Bed-Material Entrainment in Selected Streams of the Edwards Plateau, Kimble, and Real Counties, Texas, and Vicinity**

*TEXAS DEPARTMENT OF TRANSPORTATION (TXDOT)*

*USGS 4695-4 • 2008*

The Texas Department of Transportation spends considerable money for maintenance and replacement of low-water crossings of streams in the Edwards Plateau in Central Texas as a result of damages caused in part by the transport of cobble- and gravel-sized bed material. An investigation of the problem at low-water crossings was made by the U.S. Geological Survey in cooperation with the Texas Department of Transportation, and in collaboration with Texas Tech University, Lamar University, and the University of Houston. The bed-material entrainment problem for low-water crossings occurs at two spatial scales-- watershed scale and channel-reach scale. First, the relative abundance and activity of cobble- and gravel-sized bed material along a given channel reach becomes greater with increasingly steeper watershed slopes. Second, the stresses required to mobilize bed material at a location can be attributed to reach-scale hydraulic factors, including channel geometry and particle size. The frequency of entrainment generally increases with downstream distance, as a result of decreasing particle size and increased flood magnitudes. An average of 1 year occurs between flows that initially entrain bed material as large as the median particle size, and an average of 1.5 years occurs between flows that completely entrain bed material as large as the median particle size. The Froude numbers associated with initial and complete entrainment of bed material up to the median particle size approximately are 0.40 and 0.45, respectively.

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## *Item 23*

### **Alternative Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas using PRESS Minimization**

TEXAS DEPARTMENT OF TRANSPORTATION (TXDOT)

USGS 5521-2 • 2008

The U.S. Geological Survey, in cooperation with the Texas Department of Transportation and in partnership with Texas Tech University, investigated a refinement of the regional regression method and developed alternative equations for estimation of peak-streamflow frequency for undeveloped watersheds in Texas. A common model for estimation of peak-streamflow frequency is based on the regional regression method. The current (2008) regional regression equations for 11 regions of Texas are based on log<sub>10</sub> transformations of all regression variables (drainage area, main-channel slope, and watershed shape). Exclusive use of log<sub>10</sub>-transformation does not fully linearize the relations between the variables. As a result, some systematic bias remains in the current equations. The bias results in overestimation of peak streamflow for both the smallest and largest watersheds. The bias increases with increasing recurrence interval. The primary source of the bias is the discernible curvilinear relation in log<sub>10</sub> space between peak streamflow and drainage area. Bias is demonstrated by selected residual plots with superimposed LOWESS trend lines. To address the bias, a statistical framework based on minimization of the PRESS statistic through power transformation of drainage area is described and implemented, and the resulting regression equations are reported. Compared to log<sub>10</sub>-exclusive equations, the equations derived from PRESS minimization have PRESS statistics and residual standard errors less than the log<sub>10</sub> exclusive equations. Selected residual plots for the PRESS-minimized equations are presented to demonstrate that systematic bias in regional regression equations for peak-streamflow frequency estimation in Texas can be reduced. Because the overall error is similar to the error associated with previous equations and because the bias is reduced, the PRESS-minimized equations reported here provide alternative equations for peak-streamflow frequency estimation.

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## *Item 24*

### **Using Profile Measurements to Locate and Measure Grind and Fill Areas to Improve Pavement Ride**

UNIVERSITY OF TEXAS AT ARLINGTON (UTA)

UTA 4463-1 • 2008

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. This research develops a method which can integrate data from a scanning laser or multi-path profiles with a gyroscope and inertial profiler for viewing three-dimensional pavement surfaces for overlay and milling strategies.

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