



# Research Digest

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**TxDOT Reports**

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## *Item 1*

**Right-of-Way Acquisition and Utility Adjustment Process Duration Information Tool (RUDI) User Guide**  
*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)*  
*CTR 4617-01-P1 • 2008*

“Right of Way and Utility Adjustment Duration Information System” (RUDI) is an innovative tool that reviews a historical data directory to make intelligent predictions of time to acquire R/W and adjust utilities. RUDI is the first functional model of this type of decision assistance tool. RUDI is believed to be a wise first step toward providing a knowledgeable advisory of R/W project completion thereby supporting the mission of TxDOT to work cooperatively to provide safe, effective and efficient movement of people and goods. This guide includes chapters on getting started with RUDI, navigating RUDI, and using RUDI.

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[http://www.utexas.edu/research/ctr/pdf\\_reports/5\\_4617\\_01\\_P1.pdf](http://www.utexas.edu/research/ctr/pdf_reports/5_4617_01_P1.pdf)

## *Item 2*

**Effects of Increasing the Allowable Compressive Stress at Release on the Shear Strength of Prestressed Concrete Girders**  
*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)*  
*CTR 5197-3 • 2008*

In recent years, several research projects have been conducted to study the feasibility of increasing the allowable compressive stress in concrete at prestress transfer, currently defined as 0.60f<sub>ci</sub> in the AASHTO LRFD Bridge Design Specifications. Increasing the limit would result in many economical and design benefits for the precast concrete industry, such as increased span lengths and faster turnover of beams in stressing beds. This research study focuses on the effects of increasing the allowable compressive stress at release on the shear strength of prestressed concrete members, a topic which has not yet been explored by past research projects. The current experimental work is funded under TxDOT Project 5197, which initiated in 2004 at the University of Texas at Austin.

In the shear performance evaluation, 18 shear tests were performed. In the shear tests, the beams were loaded to fail in web-shear, with a shear span to depth ratio of 2.22. The diagonal cracking shears and shear capacities were experimentally measured for all specimens tested. All test specimens were TxDOT Type-C highway bridge girders (40-inch deep pretensioned I-beams) and were fabricated by three different precast plants in Texas. The compressive stress at release for the test specimens ranged from 0.56f<sub>ci</sub> to 0.76f<sub>ci</sub>. The measured cracking shears and shear capacities were compared to the estimated cracking shears and shear capacities, as calculated using ACI 318-08 and AASHTO LRFD (2007), and the effects of higher release stresses on shear strength and serviceability were evaluated by examining the conservativeness and accuracy of the predictions. Based on the experimental results summarized in this report, an increase in the allowable maximum compressive stress in concrete in the end regions of prestressed concrete beams at prestress transfer to 0.65f<sub>ci</sub> or 0.70f<sub>ci</sub> can be justified.

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## **Item 3**

### **Investigation of the Internal Stresses Caused by Delayed Ettringite Formation in Concrete** *UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)* *CTR 5218-1 • 2008*

Delayed ettringite formation (DEF) in concrete has been identified in recent as a significant cause of deterioration in some of the reinforced concrete infrastructure in Texas. This report is part of a research project, TxDOT project 5218, to investigate the possible long-term structural and durability related effects of DEF in such structures. The focus of this particular report is the determination of the internal stresses caused by DEF which at this point in time are not known. The research presented here began by first looking at past and recent research involving concrete deterioration due to alkali-silica reaction (ASR) and discussing the results of a comparative study between DEF and ASR affected concrete with different dosages of steel fibers to provide restraint. The study then went on to directly study the stresses caused by DEF in a new testing methodology that was developed using a Hoek tri-axial load cell to provide a direct measurement of the confining stress necessary to stop DEF induced expansion. In addition to the steel fiber and Hoek cell testing, reinforced concrete elements were made to study the structural effects of DEF. Lastly, a series of tests performed at the University of New Brunswick were performed to assess the stresses generated by DEF and the requisite levels of confinement needed to resist these stresses. The following report outlines the process, results, and lessons learned from the conducted tests.

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## **Item 4**

### **Recommendations for the Use of Precast Deck Panels at Expansion Joints** *UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH (CTR)* *CTR 5367-1 • 2008*

Prestressed concrete panels have been used by the bridge construction industry in the state of Texas for many years to increase construction speed and improve safety and economy. At expansion joints, cast-in-place concrete is used and requires temporary formwork and slows construction. In a previous TxDOT project (0-4418), a fullscale bridge deck was constructed that included precast panels at a 0o skew. The results indicated that the precast panel system provided adequate strength and reduced construction costs compared with the traditional cast-inplace details at the expansion joint. In this investigation (TxDOT Project 0-5367) two areas not covered in Project 0-4418 were studied: fatigue performance of bridge decks using precast panels at the expansion joints and the use of precast panels at skewed expansion joints. Fatigue response of precast panels under loading at the expansion joint in 0o skew bridges was excellent. Skewed precast panels at expansion joints were tested under static and fatigue loads. Two skew angles were tested: 30o and 45o. Six specimens were constructed and subjected to a total of eleven tests. Loads were applied at midspan of the skewed end of each specimen, and some specimens were also loaded at joint between trapezoidal (skewed) panels and an adjacent rectangular panel. The skewed panels performed well. Design recommendations for implementation of skewed panels were developed.

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## **Item 5**

### **Literature Review on Concrete Pavement Overlays Over Existing Asphalt Pavement Structures**

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

CTR 5482-1 • 2008

The primary objective of this report is to summarize the findings of the literature review on the performance of whitetopping test sections and design procedures. Two questions face pavement engineers who consider using Portland cement concrete (PCC) overlays over hot mix asphalt concrete (HMAC): (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. TxDOT developed design standards and special specification for thin white topping. However, TxDOT currently does not have guidelines or design procedures for the rehabilitation of HMAC showing rutting and shoving, with TWT.

Several whitetopping projects were constructed over the years. The performance of these projects was investigated. They include test sections in Illinois, Minnesota, and Colorado. Several design procedures for whitetopping were reviewed: 1) Colorado whitetopping design procedures; 2) the Portland Cement Association design procedure developed by the Construction Technology Laboratories; 3) American Concrete Pavement Association design procedures; 4) design procedures developed by the New Jersey DOT, which were based on theoretical analysis. Review of these design procedures reveals that improvements are still needed for the proper and accurate determination of whitetopping pavement system.

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## **Item 6**

### **An Analysis of the Value of Texas Seaports in an Environment of Increasing Global Trade**

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

CTR 5538-1 • 2008

This study undertook an economic impact exercise for all Texas ports, updated a similar study done a decade earlier, and so assisted TxDOT with incorporating the most recent marine port impacts into their state transportation planning. The study was awarded to a joint CTR-TTI team but work did not begin until the scope was clarified by TxDOT, following concerns expressed by some members of the Texas Ports Association (TPA). Almost all the larger Texas ports had undertaken economic impact studies and were understandably concerned about any new study providing different answers. This was highly likely as economic impact output is influenced by the timing, scale, and specifications of each study. Accordingly, it was agreed that where a Texas port had already completed an economic impact study, the results would be reported to TxDOT in this project. The work also provided both a forecast of container growth at Texas terminals and an estimate of the economic impact of Texas ports on the U.S economy.

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## ***Item 7***

### **Archiving, Sharing, and Quantifying Reliability of Traffic Data**

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

*CTR 5686-1 • 2008*

Vast quantities of transportation data are automatically recorded by intelligent transportation infrastructure, such as inductive loop detectors, video cameras, and side-fire radar devices. Such devices are typically deployed by traffic management centers (TMCs), and the data used for operational studies; however, such data are also highly valuable for transportation planning and other applications. This project considered how such data can best be stored and managed to accommodate multiple users, and multiple types of detector technologies. A modular system is developed, allowing data from multiple TMCs to be collected, translated into a common format, and placed in a central archive. Additionally, a novel method for quantifying data reliability is described, as error detection is critical when managing large quantities of data. Multiple techniques are also described for imputing missing data, or correcting erroneous data. Issues related to implementation are also discussed, along with innovative detector technologies that may be deployed in the near future, and thus must be considered when developing a flexible archival system.

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## ***Item 8***

### **Crackscope Automatic Pavement Cracking Inspection System**

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

*CTR 5708-P4 • 2008*

The CrackScope system is an automated pavement crack rating system consisting of a digital line scan camera, laser-line illuminator, and proprietary crack detection and classification software. CrackScope is able to perform real-time pavement inspection with 100% distance coverage at travel velocities from 3 to 70 mph. It covers a 10- to 12-foot wide lane with a resolution of 1.5 mm to 1.75 mm/pixel. The system consumes approximately 200 w electrical power ( $12\pm 0.5$  VDC), and can perform both daytime and nighttime survey.

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## **Item 9**

### **Synthesis of Workload Reduction Strategies for Construction Inspection**

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

CTR 5799-1 • 2008

State departments of transportation (DOTs) have seen significant funding increases throughout the past decade. The additional funding has also brought about an increase in the construction inspection and testing workload, but the DOTs have not seen a sufficient increase in personnel to manage the additional work. As a result, TxDOT was motivated to identify efficient strategies for reducing the construction testing and inspection workload without decreasing the quality of the end product. This study investigated current practices in other state DOTs and summarized workload reduction strategies that have the potential for efficiently reducing inspection workload within TxDOT.

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## **Item 10**

### **Characterization of Undrained Shear Strength Profiles for Soft Clays at Six Sites in Texas**

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

CTR 5824-2 • 2009

TxDOT frequently uses Texas Cone Penetrometer (TCP) blow counts to estimate undrained shear strength. However, the current correlations between TCP resistance and undrained shear strength have been developed primarily for significantly stronger soils than are often encountered at shallow depths. Updated existing correlations would allow TxDOT to estimate better the undrained shear strength of soft soils for the design of embankments and retaining structures. Considering the limited data for these soils, the primary objective of this study was to characterize the undrained shear strength profiles for six sites with strengths generally less than 750 psf, such as those commonly found at depths up to approximately 30 feet. The undrained shear strength profiles developed in this study were used in further research by Garfield (2008) to develop and assess the reliability of new correlations between Texas Cone Penetrometer resistance and undrained shear strength of soft clays.

An analysis was performed comparing strengths measured in unconsolidated-undrained, consolidated-undrained, field vane shear, and piezocone penetration tests with respect to strengths from the average strength profiles. The degree of sample disturbance in unconsolidated-undrained tests was assessed based on values of axial strain at 75 percent of the principal stress difference at failure. While there was significant scatter in the data, unconsolidated-undrained tests gave strengths that tended to be significantly lower than strengths from the average profiles. The degree of sample disturbance in consolidated-undrained tests was assessed based on the volumetric strain during consolidation to the in-situ effective overburden stress. Consolidated-undrained tests on disturbed specimens gave strengths that were approximately 50 percent higher than what was believed to be the correct strength. Strengths measured in field vane shear tests were corrected with Bjerrum's (1972) correction factor and found to generally agree well with strengths from the average strength profiles. However, vane tests in sandy clays tended to overestimate undrained strengths. Analyses also indicated that piezocone penetration tests can be used to establish reasonably accurate undrained shear strength profiles without the need for site specific correlations.

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## *Item 11*

### **PAVECHECK: Integrating Deflection and GPR for Network Condition Surveys**

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

TTI 4495-01-2 • 2009

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 this study Global Positioning System (GPS) was added to the system, and both the existing data collection and data processing programs were modified. One goal of this study was to evaluate the potential of using the upgraded PAVECHECK system to collect network level pavement condition data to assist in pavement rehabilitation planning. GPR data were collected on the entire roadway network for Williamson County in the Austin District. Collecting the entire 400 center lane miles took less than 10 days. Maps showing the limits of the data collection activities were developed. The upgraded system and the outputs from Williamson county are described in this report. The collected data and upgraded software has been delivered to district personnel.

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 12*

### **PAVECHECK: Training Material Updated User's Manual Including GPS**

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

TTI 4495-01-P2 • 2009

PAVECHECK is a software package used to integrate nondestructive test data from various testing systems to provide the pavement engineer with a comprehensive evaluation of both surface and subsurface conditions.

This User's Manual is intended to demonstrate how to load data into PAVECHECK and how to use the many functions available within the system. The PAVECHECK software is provided on a CD that accompanies this report. The PAVECHECK executable module will load the program and two folders containing test data into the default C:\PAVECHECK\ directory. The US77 folder is intended to represent a typical new data set that will need to be input into PAVECHECK. These data are used to demonstrate how to create a project file and view data. The ANNEX folder contains an already existing comprehensive project file that includes FWD data.

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## ***Item 13***

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

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

TTI 4701-5 • 2009

This project was established to provide a means of conducting limited scope evaluations of numerous traffic control device issues. During the fifth, and final, year of the project, researchers conducted four activities: improving the interface for the automated process for identifying the start and end of no-passing zones developed during the fourth year, continuing the evaluation of the performance of lead-free yellow thermoplastic pavement markings started at the end of the fourth year, continuing development of the Work Zone Implementation Handbook, and creating an updated edition of the Sign Crew Field Book. The last two of these activities produced stand-alone documents for Texas Department of Transportation (TxDOT) use. The evaluation of lead-free thermoplastic found that the material performs well in most, but not all, areas. The improved interface for the automated no-passing zone was tested in the field at two sites, and the results indicate that the results are consistent with existing no-passing zone markings when considered for vertical alignment only.

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## ***Item 14***

### **Incorporating Safety into the Highway Design Process: Fifth-Year Report**

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

TTI 4703-6 • 2008

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 3800 motorists die annually on Texas highways. As part of its proactive commitment to improving highway safety, the Texas Department of Transportation (TxDOT) is moving toward including quantitative safety analyses throughout the project development process. This research project has as its objectives: (1) the development of safety design guidelines and evaluation tools to be used by TxDOT designers, and (2) the production of a plan for the incorporation of these guidelines and tools in the planning and design stages of the project development process.

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## **Item 15**

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

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

TTI 5292-2 • 2008

This report describes the second and final year activities of the project titled "Using Operations-Oriented Performance Measures to Support Freeway Management Systems." Work activities included developing a prototype system architecture for testing the use of performance measures in real-time. Outputs from this effort included operator's screens, a prototype database, and a concept of operations for using the real-time measures. Additional work showcased the application of a multi-criterion screening approach to the selection of competing performance measures.

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## **Item 16**

### **Evaluation of Binder Aging and Its Influence in Aging of Hot Mix Asphalt Concrete: Literature Review and Experimental Design**

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

TTI 6009-1 • 2009

Binder oxidation in pavements and its impact on pavement performance has been addressed by numerous laboratory studies of binder oxidation chemistry, reaction kinetics, and hardening and its impact on mixture fatigue. Studies also have included some work on binder oxidation and hardening in pavements and the effectiveness of maintenance treatments. Yet more such studies are needed to better understand the fundamentals of pavement performance as a function of climate and pavement parameters.

Based on these reports in the literature, an experimental design has been developed to meet three objectives and to provide four products. The objectives are: 1) to develop and calibrate a laboratory test to assess binder aging during the production process and during the field service of the pavement; 2) to incorporate aging for use in a HMA mix design system to produce mixtures that provide adequate resistance to fatigue cracking, including guidelines to optimize resistance of HMA to aging; and 3) to evaluate the use of maintenance treatments to reduce the aging of asphalt pavements starting at early ages.

The products: 1) a new test procedure to characterize binder aging, and predict service life for different applications; 2) an HMA mix design component that incorporates aging and its effect on resistance to fatigue cracking; 3) guidelines for optimizing HMA mixture resistance to aging; and 4) guidelines for the best maintenance treatments to reduce the aging of binders.

The experimental design includes measurements of binder oxidation and hardening at various stages of binder service, fundamental studies of binder oxidation and hardening kinetics, developing a transport model of binder oxidation in pavements, measurements of field oxidation and hardening rates, measurements of mixture fatigue decline as a function of binder oxidative hardening in both the field and laboratory, and measurements of maintenance treatment effectiveness at retarding binder oxidative hardening.

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## ***Item 17***

### **Synthesis on Construction Unit Cost Development Technical Report**

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

*TTI 6023-1 • 2009*

Availability of historical unit cost data is an important factor in developing accurate project cost estimates. State highway agencies (SHAs) collect data on historical bids and/or production rates, crew sizes and mixes, material costs, and equipment costs, including contractor overhead and profit. The goal of this synthesis is to identify how state highway agencies develop unit prices for construction and maintenance projects. The synthesis approach consists of a comprehensive online survey, covering every aspect of unit cost development, to identify the state of practice in state highway agencies and interviews with several representative SHAs to gain a better understanding of the practices followed for unit cost development. This study finds that even though SHAs collect and store historical cost data, they do not have a formal and documented process for adjusting unit costs for project characteristics and market conditions.

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## ***Item 18***

### **Establishing Advisory Speeds on Non Direct-Connect Ramps: Technical Report**

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

*TTI 6035-1 • 2009*

Current procedures for setting ramp advisory speeds in the state of Texas are outlined in the Texas Department of Transportation's official procedures for establishing speed zones. For ramps, these procedures suggest using exit speed or ramp speed signing where an engineering investigation shows the necessity of advising drivers of the maximum recommended speed on a ramp. Research conducted under this investigation involved speed studies of ramps with a broad range of horizontal and vertical curvatures, frontage road to freeway speed differentials and distances between the ramp and the downstream cross street in order to create a predictive model of ramp speed. Utilizing the degree of curvature (if any) found along the ramp and the distance along the ramp from the freeway exit ramp gore to the downstream intersection along the ramp or frontage road, analysts use the predictive model to identify the expected mean truck speed along the ramp. Based on the difference in speed between the freeway and the mean truck speed expected along the ramp, a ramp advisory speed signing scheme is recommended.

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## *Item 19*

### **Development of a Precast Bridge Deck Overhang System for the Rock Creek Bridge**

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

TTI 6100-2 • 2008

Precast, prestressed panels are commonly used at interior beams for bridges in Texas. The use of these panels provides ease of construction, sufficient capacity, and good economy for the construction of bridges in Texas. Current practice for the overhang deck sections requires that formwork be constructed. The cost of constructing the bridge overhang is significantly higher than that of the interior sections where precast panels are used. The development of a precast overhang system has the potential to improve economy and safety in bridge construction. This research investigated the overhang and shear capacity of a precast overhang system for potential use in the Rock Creek Bridge in Parker County, Texas. Grout material characteristics for the haunch and constructability issues were also addressed. Results indicate that the capacity of the precast overhang system is sufficient to carry factored AASHTO loads with no or very limited cracking. Results from the shear study indicate that the shear capacity of threaded rods and threaded rods with couplers is lower than the conventional R-bar system. However, modifications of the initial design and layout for the end panels should provide sufficient capacity. A commercial grout has been identified for use in the haunch zone. A recommendation for the haunch form system for use on the bridge is also provided.

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