

# Research Digest

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## *Item 1*

### **Development and Testing of a Non-Pinned Low-Profile End Treatment**

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

*TTI 1002-12-7 • 2013*

The Low-profile barrier was crash tested in the 1990s to assure that a previously developed Low-Profile barrier end treatment complied with Test Level 2 (TL-2) criteria for terminals and redirective crash cushions as presented in National Cooperative Highway Research Program (NCHRP) Report 350... The Federal Highway Administration (FHWA) deemed acceptable the complete Low-Profile barrier system, including the sloped end treatment, for use in situations consistent with NCHRP Report 350 TL-2 applications in 2009. The original Low-Profile end treatment was designed and tested under the assumption that it would be attached to the pavement or subgrade using vertical steel pins spaced at equal intervals along the centerline of the end treatment. The purpose of the steel pins was to control lateral deflection of the end treatment during impact, the introduction of holes into the pavement or subgrade may not be desirable in many applications. The purpose of the research presented was to determine if a non-pinned Low-Profile end treatment can comply with applicable crash test standards. The unpinned Low-Profile end treatment performed acceptably for MASH Tests 2-34 and 2-35.

This report is available for free download (8.7 MB):

<http://tti.tamu.edu/documents/9-1002-12-7.pdf>

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## *Item 2*

### **Corrosion Resistance Recommendations from Long-Term Exposure Testing of Post-Tensioning Systems**

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

*CTR 4562-5 F • 2013*

Results from two sets of full-scale post-tensioned specimens after four and six years of highly aggressive exposure tests are summarized. The study was funded to assess corrosion resistance of both the current state of the industry and possible future developments in strands, ducts, couplers, and anchorages. Non-destructive monitoring was performed throughout the testing, followed by full autopsies of the specimens. The project also served to highlight a new, smaller test specimen and to investigate how the new specimen was able to better isolate design variables. The main focus was durability of galvanized steel ducts in comparison to plastic ducts. While the galvanized duct certainly showed much worse physical behavior, with large sections of the duct being totally breached by corrosion, the plastic duct jointing techniques failed to completely prevent chloride ingress into the grout and therefore to the tendon. Future testing of post-tensioned systems should be conducted with this new procedure and specimen since it was much more cost effective. The project results showed plastic ducts weren't subject to corrosion as a result of chlorides but were subject to minor internal gouging damage caused by threading of the strands. Both coupled and uncoupled ducts contained grouts with elevated chloride content. Regardless, the strands showed little physical damage. Additionally the project served to highlight the importance of grouting procedures and the need for proper implementation of the Post-Tensioning Institute grouting standards. Failure to address workmanship issues provided the largest contribution to corrosion damage. These results were considered in a cost analysis which demonstrated how upfront decisions and small initial cost increases can substantially increase performance life and limit corrosion issues.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Test Specimens
- Chapter 3. Companion Testing
- Chapter 4. Experimental Procedure
- Chapter 5. Exposure Test Results and Analysis
- Chapter 6. Cost Analysis
- Chapter 7. Conclusions and Recommendations
- References

This report is available for free download (4.5 MB):

<http://library.ctr.utexas.edu/ctr-publications/0-4562-5f.pdf>

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## *Item 3*

### **Application of a Performance Management Framework for Priced Lanes**

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

*TTI 6396-01-1 • 2013*

The Texas Department of Transportation and its agency partners have implemented various forms of lane management and pricing over the past three decades, including high-occupancy vehicle (HOV) lanes, high-occupancy toll lanes, managed lanes, and toll roads. As more of these complex transportation facilities are planned and constructed throughout the state, agencies need to understand how these facilities may operate over time. Ideally, the long-term operations should be based on metrics that are agreed upon in advance. When agencies define what metrics can most effectively and efficiently measure the performance of a facility and outline what thresholds trigger a change in operation may change over time. This understanding allows the facility operators to focus on the tasks of efficiently operating a smooth transportation network, rather than on how to get the necessary changes approved in a timely manner. Research Project 0-6396 developed a framework called the Traffic Thermostat, which can help make operating decisions for priced facilities and can guide changes in operational strategies for a facility over time. This implementation project demonstrates how the Traffic Thermostat can be implemented for a specific project, and allowed for adjustments to the framework and implementation process based on results. This pilot focused on the I-30 managed HOV lanes. In addition, the project created a primer and user's manual to assist agencies in using the Traffic Thermostat.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Project Planning and Literature Review
- Chapter 3. Technical Advisory Committee
- Chapter 4. Development of the Traffic Thermostat Primer
- Chapter 5. Application of the Traffic Thermostat Framework
- Chapter 6. Feedback on Outreach Materials
- Chapter 7. Conclusion
- Appendix A. Traffic Thermostat Primer
- Appendix B. Traffic Thermostat User's Manual

This report is available for free download (730 KB):

<http://tti.tamu.edu/documents/5-6396-01-1.pdf>

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## **Item 4**

### **Texas Traffic Thermostat Software Tool**

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

*TTI 6396-01-P1 • 2013*

This CD-ROM contains the software developed under TxDOT Research Project 0-6396. "To support its Mobility Pledge to Texas commuters, TxDOT has created a tool for traffic managers that helps them meet operational goals established for roadways by local communities. Dubbed the Traffic Thermostat Decision Tool, this software enables managers to implement simulated solutions to determine how best to change operations in the real world to meet performance goals."

#### CONTENTS

- 0-6396-P1 TPs.pdf [Talking Points]
- 5-6396-01-P1 front.pdf [publication title page, disclaimers, acknowledgments]
- 5-6396-01-P1 User Manual.pdf [Use of the Traffic Thermostat Decision Tool]
- Data\_111813\_161710.roxio
- ReadMe.txt [Traffic Thermostat Tool system requirements]
- thermostat 040413.zip [software]

This report is available for free download (1.9 MB):

<http://tti.tamu.edu/documents/5-6396-01-P1.zip>

## **Item 5**

### **Texas Traffic Thermostat Marketing Package**

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

*TTI 6396-01-P2 • 2013*

This CD-ROM compiles documents from TxDOT Research Project 0-6396 and Implementation Project 5-6396-01, including an example FAQ document "A Traffic Thermostat for Texans," a press release template, and a PDF of presentation slides for the presentation "A Traffic Thermostat for Texas: Using Performance Measures to Enhance Mobility."

#### CONTENTS

- 0-6396\_FAQ.pdf
- 0-6396-P1 press release.docx
- 5-6396-01-P2 front.pdf
- 5-6396-01-P2 Traffic Thermostat.pdf
- Data\_111813\_161904.roxio

This report is available for free download (1.7 MB):

<http://tti.tamu.edu/documents/5-6396-01-P2.zip>

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## *Item 6*

### **Pullout Resistance of Mechanically Stabilized Reinforcements in Backfills Typically Used in Texas. Volume 1, Research Report**

TEXAS TECH UNIVERSITY. CENTER FOR MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION (TECHMRT)  
*TechMRT 6493-1 v.1 • 2013*

This report documents findings from a three-year research study that examined the pullout resistance of inextensible MSE reinforcements in backfills typically used in Texas. The study involved an extensive laboratory test program in which a total of 650 pullout tests were completed. These tests were conducted using a large scale pullout test system that consisted of a test box with dimensions of 12ft x 12ft x 4ft and capability to simulate overburden pressures equivalent to 40 feet of fill. Tests were conducted on ribbed strip reinforcements, welded steel grid reinforcements, and a limited number of smooth bars embedded in two types of backfill, designated as Type A (gravelly) and Type B (sandy) select backfill as per TxDOT specifications. A subset of strip and grid reinforcements in each backfill type was instrumented with strain gages to provide further insight into mechanisms that control pullout resistance. The research design evaluated pullout resistance factors for both strip and grid reinforcements for a variety of independent variables including overburden pressure, reinforcement length, skew or splay angle, grid wire size, and grid geometry including both transverse and longitudinal wire spacing. Appropriate statistical analyses were used to interpret the data within the context of published AASHTO design guidance for inextensible MSE reinforcements. This volume, Volume 1, summarizes the research findings. Volume 2 and Volume 3 present the test reports for MSE reinforcements in Type B and Type A backfill, respectively.

This report is available for free download (9.6 MB):

<http://www.depts.ttu.edu/techmrtweb/Reports/Complete%20Reports/0-6493-1.pdf>

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## *Item 7*

### **Improvements of Full Depth Repair Practices for CRCP Distresses**

TEXAS TECH UNIVERSITY. CENTER FOR MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION (TECHMRT)  
*TechMRT 6611-1 • 2013*

The Texas Department of Transportation (TxDOT) has by far the most continuously reinforced concrete pavement (CRCP) lane miles in the nation and sections as old as 50 years are still in service. Having served much longer than intended, some sections are showing distresses. FDR (full depth repair) is one of the methods to repair CRCP distresses in Texas. Over the years, various FDR methods have been used and the effectiveness of each method has varied. The most widely used FDR method – where a full-depth cut is made at 2 ft (30.48 cm) inside the transverse repair boundaries and partial-depth cut at repair boundaries with the concrete in between removed to expose longitudinal steel – has inherent disadvantages, with longer repair time required being the primary disadvantage. Full-depth cut FDR method – where a full-depth cut is made at repair boundaries with transverse and longitudinal tie bars epoxy grouted into the existing concrete – has advantages over other methods, one of which is the faster operation, minimizing the time of roadway closure. Since CRCP is normally utilized at high traffic volume areas, the maximum time allowed for the FDR operation in TxDOT is normally limited to nine hours, which makes the full-depth cut method the only acceptable repair method. Factors affecting the effectiveness of the full-depth cut method were investigated by laboratory testing and field evaluations. The way epoxy is injected into the holes was the most important variable affecting the performance of FDR. Based on the research findings, recommendations were made to revise specifications for FDR, and it is expected that the implementation will result in improved FDR performance of CRCP. Some distresses in CRCP are limited to the upper half of the slab depth, and for these distresses, partial depth repair (PDR) is the more effective method. A device called MIRA was evaluated for the detection of partial depth failures in CRCP. MIRA was able to detect not only delaminations, but voids and mud balls in concrete slab, reinforcement, and slab thickness. For the detection of partial depth distresses, MIRA can be a useful tool. Guidelines, special specifications, and design standards for PDR were developed.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. FDR Practices in Other States
- Chapter 3. Evaluation for FDR Performance
- Chapter 4. Partial Depth Repairs
- Chapter 5. Conclusions and Recommendations

This report is available for free download (7.6 MB):

<http://www.depts.ttu.edu/techmrtweb/Reports/Complete%20Reports/0-6611-1.pdf>

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## **Item 8**

### **An AHP-based Approach to Prioritizing Resources for Highway Routine Maintenance**

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

*CTR 6623-2 • 2013*

The Texas Department of Transportation has been experiencing maintenance budget fluctuations recently. The budget shortage has a negative impact on the agency's maintenance strategies and results in the undesirable deterioration of highway conditions, increasing the risk for both road users and the agency. This project aims to develop a methodology to minimize the impact of budget fluctuation by quantifying the risk of not performing a maintenance activity and identifying the priority of maintenance activities based on the quantified risk. With the help of maintenance experts from TxDOT, 4 maintenance objectives and 16 maintenance function groups were identified and a hierarchy structure was developed based on the objectives and function groups. Four pilot districts were selected to represent the different demographic and climatic regions in Texas and maintenance experts were selected from the four districts to participate in the workshop. The overall relative weights of the 16 maintenance function groups were determined based on the individual evaluator's judgments using the Analytical Hierarchy Process. To determine whether the 4 pilot districts varied in assigning relative importance to the 4 defined objectives and priority to the 16 maintenance groups, statistical analyses were conducted with the 4 sets of values, 1 for each of the 4 pilot districts, using Kruskal-Wallis test. Lastly, a web-based prototype system was developed to assist users in generating the list of maintenance projects under budget constraints. Exposure factors, ADT, and truck volume were applied in the system to factor in the impact of traffic on the maintenance strategy. Users of this system can choose to use the weights and parameter values from the pilot district that they think is most comparable to their own district, or use the state average values that have proved to be applicable to all the districts in Texas.

This report is available for free download (2.2 MB):

<http://library.ctr.utexas.edu/ctr-publications/0-6623-2.pdf>

## **Item 9**

### **Optimizing Concrete Pavement Type Selection Based on Aggregate Availability**

TEXAS TECH UNIVERSITY. CENTER FOR MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION (TECHMRT)

*TechMRT 6681-1 • 2013*

Design concept and structural responses of jointed plain concrete pavement (CPCD) and continuously reinforced concrete pavement (CRCP) are quite different. In CPCD, concrete volume changes are allowed to a full extent, and accommodations are made to ensure good load transfer at discontinuities, i.e., transverse contraction joints. On the other hand, concrete volume changes are restrained to a significant degree in CRCP by longitudinal reinforcement and base friction. Because of this vastly different behavior between the two pavement types, concrete with a high CoTE is not an ideal material for CRCP. In other words, the performance of CRCP with a high CoTE concrete will be compromised, with resulting spalling. Concrete with a high CoTE should be used for CPCD if at all possible. This study investigated the correlation between spalling and concrete CoTE. CRCP sections with severe spalling were identified. Sections with no spalling and delamination distresses were also identified. A minimum of two cores were taken from those sections, and CoTE and modulus of elasticity were evaluated. There was an excellent correlation. Concrete material properties of selected coarse aggregates were extensively evaluated in the laboratory. Also, an in-depth analysis was made of the life-cycle cost of the pavement with coarse aggregates from different sources. Concrete with a CoTE larger than 5.5 microstrain per °F is quite prone to severe spalling.

This report is available for free download (4.8 MB):

<http://www.depts.ttu.edu/techmrtweb/Reports/Complete%20Reports/0-6681-1%20Final.pdf>



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## ***Item 10***

### **Container Terminal and Cargo-Handling Cost Analysis Toolkit**

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

*CTR 6690-CTR-P2/P1 • 2013*

"For this task [on TxDOT Project 0-6690], the study team sought to determine the costs associated with container terminal operations and their influence on overall container shipping cost. Commercial ports publish prices (tariffs) for a wide variety of services and the study proposal included the development of a spreadsheet that would allow freight planners to build policy-based strategies to capture the impacts of current and new maritime services on Texas Gulf ports. This approach allows a technical dialog to be developed between TxDOT/MPO staff and the port/shipping sectors. Published port terminal activity costs (tariffs) should, however, be regarded as nominal—they may not reflect actual prices charged to a steamship company or major shipper. Negotiated prices reflect a range of factors, such as customer size, that are confidential. Fortunately, nominal prices do work for strategic planning because they show the cost differentials between ports that drive port selection on supply chains. Accordingly, the study team developed a basic model or toolkit that could be evaluated by TxDOT planners. The Container Terminal and Cargo-Handling Cost Analysis model was developed using tariffs from select Texas ports and the results are now presented." --p1

This report is available for free download (ZIP file includes PDF and Excel file):

<http://library.ctr.utexas.edu/ctr-publications/0-6690-p1p2.zip>

## ***Item 11***

### **Linking Long-Range Transportation Planning with Project Planning in Support of the Environmental Review Process**

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

*CTR 6701-1 • 2013*

This report investigates potential methods of linking transportation planning in Texas, principally long-range planning, with the environmental clearance process required of the National Environmental Policy Act (NEPA). The purpose of the research is to achieve time and monetary savings by streamlining the NEPA process. These savings result principally by reducing duplicative efforts performed during the transportation planning and NEPA processes. To achieve this goal, the report reviews the effectiveness of practices and initiatives in Texas and around the county designed to encourage planning documentation that supports the NEPA process. The report then assesses the challenges involved with implementing these practices in Texas and makes a series of recommendations designed to be implemented by various agencies in Texas that would provide linkages between transportation planning and the NEPA process.

This report is available for free download (1.4 MB):

<http://library.ctr.utexas.edu/ctr-publications/0-6701-1.pdf>

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## *Item 12*

### **Best Practices for TxDOT on Handling Wildfires**

TEXAS TECH UNIVERSITY. CENTER FOR MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION (TECHMRT)  
*TechMRT 6735-2 • 2013*

Texas saw a record-setting number of wildfires in 2010 and 2011. Personnel from the Texas Department of Transportation (TxDOT) are often called upon to provide support in responding to wildfires, and the number of requests has increased dramatically over the past few years. TxDOT developed a draft Guidance Document for Wildfire Response, but personnel are frequently asked to perform services not specifically addressed in that document. TxDOT took advantage of the recent increase in wildfire response experiences to document the lessons learned from wildfire events and study the role of TxDOT in the mitigation, containment, and response to wildfires. The objective of this research project was to develop a protocol to help TxDOT effectively respond to wildfire situations that may occur in the state, and to present the protocol in the form of “Best Practices” based on information gathered from many sources both within TxDOT and from agencies outside the department. Using the information collected, researchers developed a training course for TxDOT personnel who deal with wildfire situations. A pilot course was presented to the Project Monitoring Committee, and based on feedback from that pilot course, six training modules were developed to present as training for TxDOT supervisors, assistants, and district safety coordinators. A significant and repeated finding is that TxDOT employees are not expected to fight fires directly and have no such responsibilities. Emphasis on employee safety is paramount.

#### CONTENTS

- Chapter 1 Introduction and Project Summary
- Chapter 2 Discussion of Pilot Workshop
- Chapter 3 Training Workshop Modules
- Chapter 4 Conclusions and Recommendations
- References
- Appendix A. Presentation for Pilot Workshop
- Appendix B. Handouts for Pilot Workshop
- Appendix C. Training Modules

This report is available for free download (22.1 MB):

<http://www.depts.ttu.edu/techmrtweb/Reports/Complete%20Reports/0-6735-2%20Final.pdf>

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## *Item 13*

### **TxDOT Wildland Fire Management Training**

TEXAS TECH UNIVERSITY. CENTER FOR MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION (TECHMRT)

*TechMRT 6735-P1 • 2013*

This publication provides screenshots of slides from a "TxDOT Wildland Fire Management Training" workshop presentation aimed at Directors of operations/maintenance, area engineers, maintenance managers, maintenance supervisors, assistants and crew chiefs.

#### CONTENTS

- Module 1. Introduction
- Module 2. Organization and Communication
- Module 3. Resources and Equipment
- Module 4. Safety
- Module 5. Documentation and Data Collection
- Module 6. Training Programs

This report is available for free download (11.8 MB):

<http://www.depts.ttu.edu/techmrtweb/Reports/Complete%20Reports/0-6735-P1%20Final.pdf>

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## *Item 14*

### **Developing Emerging Transportation Technologies in Texas**

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

*CTR 6803-1 • 2013*

Texas' 83rd Legislature charged TxDOT with examining and evaluating innovative transportation technologies for purposes of cost savings, reducing traffic congestion, enhancing safety, and increasing economic productivity. As a result, the Texas Transportation Task Force was formed encompassing a group of experts who discussed four groups of emerging transportation technologies including connected vehicles, autonomous vehicles, electric systems, and cloud computing/ crowdsourcing technologies. A report of findings is provided from the Task Force's assessment of each of these technologies using a four-stage process. The first stage sought to understand technology development phases as each technology progressed from prototyping to public road testing to initial deployment and commercialization. The second stage assessed current and near-term (2018) technology maturity development from the perspective of both TxDOT and potential consumers. While the first two stages focused on these technologies as stand-alone technologies, the final two stages provided an assessment of them as standalone and combined technologies to discover synergistic effects and potential benefits and new systems that could be enabled. The third stage evaluated how individual joint technologies could serve Texas' statewide goals, and the fourth stage provided and evaluation of issues and concerns for each technology or joint technology as they progressed through development stages. Finally, the Task Force developed a preliminary short- and long-term vision for these technologies in Texas, which includes a menu of options for testing and implementation of new technologies.

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- Executive Summary
- Chapter 1. Background and Context of Transportation Technology
- Chapter 2. Technology Classification and Technology Evaluation and Assessment
- Chapter 3. Next Steps
- Appendix A. TTTF Biographies
- Appendix B. Technology Classifications and Joint Technology Impacts
- Appendix C. Goals, Issues, and Concerns Facing Emerging Technologies
- References

This report is available for free download (2.1 MB):

<http://library.ctr.utexas.edu/ctr-publications/0-6803-1.pdf>