

MARCH 2026

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### Recent TxDOT Research Publications

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### **Item 1. Improving Testing Requirements in Item 300 of TxDOT Standard Specifications**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH  
CTR 7073-1 | 2025*

Current test procedures in TxDOT specification Item 300, "Asphalts, Oils, and Emulsions" were reviewed for relevance, applicability, accuracy, and practicality, and recommendations were made for improving the tests and specifications. New test procedures were developed, as identified, to fulfill needed changes. Data for new proposed test procedures was generated and analyzed to develop suggested specification limits. This data explored the agreement between laboratories, developed test conditions, and facilitated round-robin experiments. Suggested changes were made for each table of the material specifications. A new long-term aging test was developed for PG binders.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Background
- Chapter 3. New Test Procedures and Proposed Changes for Item 300
- Chapter 4. Development of the New Test procedures in Item 300
- Chapter 5. Draft of Revised Item 300
- Chapter 6. Evaluation of New Generation of Aging Protocol
- Chapter 7. Summary and Conclusions
- Appendix A. Test Procedure for Measurement of Polymer Separation on Heating in Modified Asphalt Systems [Tex-540-C]
- Appendix B. Test Procedure for Recovery of Asphalt Residue from Asphalt Emulsion and Cutback Asphalt by Vacuum Oven [Tex-55C-C]
- Appendix C. Test Procedure for Viscosity Determination of Asphalt Emulsion and Cutback Asphalt Using Rotational Viscometer
- Appendix D. Test Procedure for Low Temperature DSR Testing of Asphalt Binder [Tex-55A-C]
- Appendix E. Test Procedure for Poker Chip Test of Asphalt Binder [Tex-55B-C]

This report is available for free download (234 pages, 5.3 MB):

<https://library.ctr.utexas.edu/ctr-publications/0-7073-1.pdf>

More information about this publication available in the [TxDOT Research Library - Publication Details](#).

### Item 2. The Service and Ultimate Behavior of Bent-to-Column Joints in TxDOT Substructures

UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH  
CTR 7113-1 | 2026

This research examined the service and ultimate behavior of bridge bent-to-column connections in Texas Department of Transportation (TxDOT) substructures to develop design recommendations for improved structural resilience under extreme events, including flooding, vehicular collision, and loss of column. A three-phase approach was employed. First, analytical studies, including plastic collapse mechanism and nonlinear dynamic analyses, were conducted on typical multi-column bents to quantify the vulnerability of poorly detailed connections and establish the foundation for a capacity-based plastic design approach and an analysis procedure for loss-of-column scenarios. Second, a large-scale experimental program tested thirteen full-scale bent-to-column specimens under lateral loads simulating vehicular collisions. The program explored various reinforcement anchorage types (straight, hooked, and headed bars) and levels of joint confinement. Third, the test results were used to validate nonlinear finite element models that further explained the observed behavior. Experimental findings revealed that TxDOT's standard connection details, though designed as pinned, are capable of moment transfer without shear failure; the column achieved their nominal moment capacity with reinforcement yielding at the face, exhibiting ductile behavior. Enhanced anchorage (hooked or headed bars) and transverse joint confinement (hoops) were shown to improve moment capacity, post-yield performance, and damage control under service loads. The study also found that current code provisions for development length are conservative for these applications. Finite element analyses accurately captured the response and identified the embedment lengths required to develop reinforcement yield strength. This research concludes that adopting a capacity-based plastic design philosophy is essential for resilient multi-column bents and connections subjected to extreme events. The findings offer actionable design guidance, including step-by-step procedures and a worked example, enabling bridge engineers to design safer, more robust substructures in future TxDOT projects.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Literature Review
- Chapter 3. Structural Analysis for Extreme Events
- Chapter 4. Experimental Program and Finite Element Analysis
- Chapter 5. Design Guidelines
- Chapter 6. Summary and Conclusion
- Chapter 7. Value of Research
- Appendix A. Draft Specifications and Example Details

This report is available for free download (186 pages, 7.1 MB):

<https://library.ctr.utexas.edu/ctr-publications/0-7113-1.pdf>

More information available in the [TxDOT Research Library - Publication Details](#)

### Item 3. Design and Evaluation of Transition for TxDOT MASH Test Level 4 (TL-4) Guardrail System

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*TEXAS A & M TRANSPORTATION INSTITUTE*

*TTI 7120-1 | 2023*

Researchers at the Texas A&M Transportation Institute (TTI) designed and tested a Manual for Assessing Safety Hardware (MASH) Test Level 3 (TL-3) compliant guardrail transition system (hereafter referred to as Transition) that enables transitioning and terminating the ends of the Texas Department of Transportation MASH TL-4 guardrail system with MASH-compliant guardrail end terminals. The researchers designed the Transition using finite element simulation analysis, details of which are presented in this report. The researchers performed vehicle impact simulations to improve the initial design concept of the Transition and developed the final design for full-scale crash testing. The researchers then constructed a test installation prototype and performed two full-scale crash tests that are also reported herein. The purpose of the tests was to assess the performance of the Transition according to the safety-performance evaluation guidelines included in the second edition of the American Association of State Highway and Transportation Officials MASH (1). The crash tests were performed in accordance with MASH TL-3 criteria, which require two crash tests: 1. MASH Test 3-20: An 1100C vehicle weighing 2,420 lb impacting the longitudinal barrier transition while traveling at 62 mi/h and 25 degrees. 2. MASH Test 3-21: A 2270P vehicle weighing 5,000 lb impacting the longitudinal barrier transition while traveling at 62 mi/h and 25 degrees. This report provides details of the Transition, the crash tests and results, and the performance assessment of the Transition for MASH TL-3 evaluation criteria for longitudinal barriers. The Transition met the MASH TL-3 performance criteria for longitudinal barriers.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Design and Simulation Analysis
- Chapter 3. System Details
- Chapter 4. Test Requirements and Evaluation Criteria
- Chapter 5. Test Conditions
- Chapter 6. MASH Test 3-20 (Crash Test 441203-01-1)
- Chapter 7. MASH Test 3-21 (Crash Test 441203-01-2)
- Chapter 8. Summary and Conclusions
- Chapter 9. Implementation
- Appendix A. Details of TL-4 Guardrail Transition
- Appendix B. Supporting Certification Documents
- Appendix C. MASH Test 3-20 (Crash Test 441203-01-1)
- Appendix D. MASH Test 3-21 (Crash Test 441203-01-2)
- Appendix E. Value of Research

This report is available for free download (143 pages, 24.2 MB):

<https://library.ctr.utexas.edu/hostedpdfs/tti/0-7120-1.pdf>

More information available in the [TxDOT Research Library - Publication Details](#).

### Item 4. Reducing Costs in Full Depth Reclamation

*TEXAS A & M TRANSPORTATION INSTITUTE*

*TTI 7143-1 | 2025*

Full depth reclamation (FDR) using emulsified asphalt or foamed asphalt continues to grow in usage throughout Texas. These mixtures typically use a cement additive in the mix design. The cement additive reportedly contributes to early strength gain, which can be particularly important for projects that require daily opening to heavy traffic. However, not all construction projects require daily opening to traffic, and some materials may provide adequate performance without the cement additive. Additionally, with potential cement supply shortages, design and construction of FDR layers using only asphalt treatments could save materials cost, reduce schedule risk, and increase daily productivity since one less step would be required in the treatment process. This project determined that without the cement additive, an additional three to four hours cure time could be required prior to opening to traffic. FDR mixes without the additive may be able to obtain similar strength and performance properties as long as they stay dry, but most common Texas materials for FDR require the cement additive to meet moisture conditioned strength requirements. If sourcing cement proves difficult, this project showed lime could be substituted 1:1 for the cement additive, although mixes with lime additive were less reliable in meeting moisture susceptibility criteria compared to mixes that used cement as the additive. In practice, emulsified or foamed asphalt-treated FDR mixes without additive could provide material cost savings, faster production, and user-delay savings, with the potential tradeoff of increased long-term performance risks due to their higher level of moisture susceptibility. Thus, no additive mixes are best considered on a case-by-case basis for low-risk areas, projects with logistical challenges for sourcing additives, or for projects where simply upgrading material properties is desired.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Literature Review
- Chapter 3. Select and Collect Materials
- Chapter 4. Comprehensive Lab Program
- Chapter 5. Temperature Influence on FDR
- Chapter 6. Economic and Structural Analysis
- Chapter 7. Conclusions and Recommendations
- Chapter 8. Value of Research
- Chapter 9. Appendix: Input Variables Used for CA4PRS
- Chapter 10. References

This report is available for free download (148 pages, 11.2 MB):

<https://library.ctr.utexas.edu/hostedpdfs/tti/0-7143-r1.pdf>

More information available in the [TxDOT Research Library - Publication Details](#).

### **Item 5. Develop a Real-Time Decision Support Tool for Urban Roadway Safety Improvements**

*TEXAS STATE UNIVERSITY*

TXST 7144- 1 | 2026

Speed-related crashes remain a critical concern for Texas, identified as one of the seven key emphasis areas in the Texas Strategic Highway Safety Plan (SHSP) for 2018–2022. Traditional crash risk models often overlook essential real-time factors such as operating speed, traffic variability, and weather, limiting their effectiveness. To address this, TxDOT Project 0-7144 integrated data from diverse sources, including NPMRDS and INRIX XD (real-time speeds), TMAS (traffic volumes), CRIS (crashes), RHINO (roadway inventory), and NOAA (weather), to develop both annual and short-duration Safety Performance Functions (SPFs) for a wide range of urban facility types. Annual SPFs were developed for urban facilities, including freeways, multi-lane divided and undivided highways, continuous left-turn lane roads, and two-lane highways, incorporating geometric and operational features such as lane and shoulder width, truck proportion, driveway density, average speed, and precipitation. This project also employed a Negative Binomial-Lindley (NBL) modeling framework to produce monthly SPFs from 2019 to 2022. These short-duration models captured the dynamic influence of seasonal factors, monthly average daily traffic (MADT), speed and travel time variability, and weather patterns on crash frequency across facility types. A key outcome of the project is the development of an interactive, GIS-based decision support tool using the Shiny platform. This tool enables users to visualize, filter, and download crash prediction outputs at both annual and short-duration levels. It offers dynamic data uploading capabilities, allowing local engineers to input updated roadway and traffic data for customized analyses. The project concludes with recommendations to update Texas SPFs for urban roadways by integrating operating speed and weather data, emphasizing speed consistency in guidelines, and expanding the tool's capacity for daily-level modeling and facility-specific diagnostics.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Literature Review
- Chapter 3. Data Preparation
- Chapter 4. Data Analysis and Model Development
- Chapter 5. Decision Support Tool
- Chapter 6. Conclusions and Recommendations
- Appendix A. HSM Safety Performance Functions
- Appendix B. Data Dictionary
- Appendix C. Decision Support Tool Scripts

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This report is available for free download (245 pages; 8.4 MB):

<https://library.ctr.utexas.edu/hostedpdfs/tsusm/0-7144-1.pdf>

More information available in the [TxDOT Research Library - Publication Details](#).

### **Item 6. ATSPM-in-the-Loop Simulation for Traffic Signal Design and Operations**

*UNIVERSITY OF TEXAS AT ARLINGTON*

*UTA 7160-P1 | 2026*

These presentation slides provide an overview of the ATSPM-in-the-loop simulation for traffic signal design and operations for TxDOT Research Project 0-7160.--cataloger's description.

#### CONTENTS

ATSPM System 101 -- Chronicle of ATSPM -- Surfacing Challenges in the ATSPM  
Deployment -- The ATSPM System and Its Digital Twin -- Traffic Microscopic Simulation  
Engine -- Set up Two ATSPM Systems in the Laboratory -- Software to Emulate Infrastructure  
Sensor Data -- Additional Notes -- Software/Hardware Options in the ATSPM Digital Twin

This report is available for free download (12 pages; 2.8 MB):

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More information available in the [TxDOT Research Library - Publication Details](#).

### **Item 7. P2: ATSPM-in-the-Loop Simulation Software Tutorial: Instructor Materials**

*UNIVERSITY OF TEXAS AT ARLINGTON*

*UTA 7160-P2 | 2026*

This is the ATSPM-in-the-loop simulation software tutorial for instructors as part of TxDOT Research Project 0-7160.--cataloger's description

#### CONTENTS

Software 1: Data Parser from VISSIM Output to UDOT-ATSPM Database -- Software Interface  
-- Transfer VISSIM RBC Signal/Trajectory Data into UDOT-ATSPM and UTA-in-Motion  
Database -- Software 2: Transfer ATSPM Data from UDOT-ATSPM to UTA-in-Motion --  
Transfer Data from UDOT-ATSPM to UTA-in-Motion -- Running Q-FREE SILS Simulation  
and Collect Real-World Traffic Signal Logs from MAXTIM Emulators -- Traffic Signal  
Performance Analysis

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### **Item 8. Select High Risk Pedestrian Midblock Crossings and Perform Safety Evaluations for Developing Pedestrian Crossings**

*UNIVERSITY OF TEXAS AT SAN ANTONIO*

*UTSA 7180-1 | 2025*

Pedestrian fatalities on high-speed, multi-lane roads in Texas, particularly in San Antonio, Houston, and Dallas, highlight an urgent need for focused interventions at midblock crossings. These sites often serve vulnerable populations and connect neighborhoods to transit, retail, and essential services, yet their safety challenges are magnified by speed, poor visibility, and insufficient infrastructure. To address this, researchers conducted a deep-dive review of safety literature, compiled extensive crash data, and leveraged geospatial tools to identify the riskiest locations across urban corridors. They developed localized Crash Modification Functions (CMFs), advanced exposure-based models, and predictive analytics tailored to Texas's unique roadway environments. A key outcome was the creation of the Midblock Crossing Pedestrian Safety Action Plan, a comprehensive guide for TxDOT districts that integrates field observations, stakeholder input, and cost-benefit analysis. This plan provides detailed site rankings, treatment prioritization strategies, and implementation pathways, including engineering upgrades, education initiatives, and enforcement considerations, grounded in local crash dynamics and pedestrian demand. Recommended treatments, such as PHBs, RRFBs, raised medians, and high-visibility markings, were evaluated for effectiveness and feasibility. The plan empowers decision-makers with a data-driven roadmap to improve safety, promote equitable access, and reduce fatalities through strategic midblock crossing improvements statewide.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. State-of-the-Practice Review
- Chapter 3. Compilation of Safety and Operational Data
- Chapter 4. Analysis of Safety and Operational Data
- Chapter 5. Identifying Midblock Safety Treatments and Determining Countermeasures
- Chapter 6. Development of Safety Performance Functions and Crash Modification Factors
- Chapter 7. Midblock Pedestrian Safety Action Plan
- Chapter 8. Conclusion
- Appendix A. Summary of Survey Results
- Appendix B. Value of Research Analysis

This report is available for free download (358 pages, 13.7 MB):

<https://library.ctr.utexas.edu/hostedPDFs/utsa/0-7180-1.pdf>

More information available in the [TxDOT Research Library - Publication Details](#).

### **Item 9. 0-7182 Guidebook for Improving the Effectiveness of Construction Management Plans (CMP)**

*UNIVERSITY OF TEXAS AT AUSTIN. CENTER FOR TRANSPORTATION RESEARCH  
CTR 7182- P1 | 2026*

"This guidebook transforms the empirical findings of TxDOT Research Project 0-7182 into an actionable manual for district and project personnel. It summarizes the key research findings and provides recommendations on how to make Construction Management Plans (CMPs) more effective. This guidebook describes the methods, data inputs, and decision recommendations practitioners need to: [1] Identify and classify potential conflicts early; [2] Describe the conflicts and management plans; [3] Use the CMP Standard Operating Procedure (SOP) to establish uniform guidelines for the development, submission, and approval of a CMP; [4] Size realistic clearance buffers; [5] Integrate conflict activities into the CPM schedule; [6] Monitor clearance progress after letting."--Introduction, page 2.

#### CONTENTS

Introduction (Purpose and Scope of the Guidebook; Audience and How to Use This Guidebook; Relationship to TxDOT CMP Standard Operating Procedure (SOP)) -- Key Findings from the 0-7182 Study (Profile of CMP Projects vs. Non-CMP Projects (Size, Complexity, Contract Value); Key Quantitative Findings) -- Recommendations (CMP Format & Content Aligned with SOP; Additional Recommendations)

This report is available for free download (11 pages, 368 KB):

<https://library.ctr.utexas.edu/ctr-publications/0-7182-P1.pdf>

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### **Item 10. Develop an Interactive Unit Price Estimation and Visualization Tool: Final Report**

*UNIVERSITY OF TEXAS AT ARLINGTON. DEPARTMENT OF CIVIL ENGINEERING  
UTA 7184-1 | 2025*

Texas Department of Transportation (TxDOT) determines unit prices of pay items using the historical bids-based estimation method and then develops an engineer's project appraisal. The engineer's estimate is used to assess the bids and select the bidder. However, the unit price of a work item is heavily affected by various project-specific and external factors, including but not limited to the project location, the quantity of the work, project complexity, time factors, and macroeconomic conditions. Therefore, accurate and reliable unit price estimation based on these

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project-specific and external factors is vital for the optimum use of the available project budget. The project objectives included: (1) conducting an overview analysis of factors affecting unit prices, (2) identifying factors affecting unit prices in Texas, (3) creating a unit price estimation database, (4) creating a spatio-temporal unit price estimation model considering the factors affecting unit prices, (5) developing a GIS-based visualization tool, and (6) implementing, demonstrating, and validating the interactive unit price estimation and GIS-based visualization tool on six Receiving Agency's projects. The models that are developed based on the identified factors affecting unit prices help enhance accurate and reliable unit price estimation. Moreover, the developed GIS-based unit price visualization tool can be used for a quick retrieval of unit price values across various geographical locations. The tool helps track changes in data over time, by county, and across projects, as well as changes in the quantity of work items.

### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Overview Analysis of Factors Affecting Unit Prices and the State DOT's Unit Price Estimation Methods
- Chapter 3. Data Collection of Historical Bid Prices and Factors Affecting Unit Prices
- Chapter 4. Machine Learning Model Development
- Chapter 5. Mixed-Effects Model Development
- Chapter 6. Development of a GIS-Based Unit Price Estimation and Visualization Tool
- Chapter 7. Implementation of the Developed GIS-Based Visualization Tool on Six TxDOT Projects
- Chapter 8. Technology Transfer
- Chapter 9. Summary and Conclusion

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## Item 11. Best Practices for Pavement Widening

TEXAS A & M TRANSPORTATION INSTITUTE

TTI 7188-1 | 2026

Premature pavement failures have occurred on several widening projects, including shoulder widenings, conversion of two-lane roadways to Super 2 sections, and other safety enhancements. Repairing these early failures is time-consuming, expensive, disrupts traffic, and poses safety hazards. Key contributing factors include poor-quality materials, poor joint construction, and inadequate drainage. These issues could have been avoided through proper pavement condition assessment, design, and construction practices, but detailed guidance on which methods to employ and which can be project specific is not readily available to district personnel. Therefore, there is a need to document and implement better widening practices across TxDOT.

### CONTENTS

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- Chapter 1. Background and Literature Review
- Chapter 2. Survey of Best Practices
- Chapter 3. Case Studies
- Chapter 4. Recommendations
- Appendix A. Survey Questionnaire

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### **Item 12. Systematic and Quantitative Approaches to Assess the Probability of Extreme Weather and Resilience Risks for TxDOT Highways and Bridges**

*TEXAS A & M TRANSPORTATION INSTITUTE*  
*TTI 7191-1 | 2025*

This research develops a quantitative framework to assess flood-related risks and resilience for Texas highways and bridges. The study reviewed current practices and gaps, applied GIS-based methods with statewide flood datasets, and evaluated exposure of pavements and bridges across multiple return periods and climate scenarios. Risk assessments quantified both acute and chronic flood impacts, including fragility curves and life-cycle cost projections that capture deterioration in different pavement types. Results show flooding is the most significant climate-related hazard to Texas transportation assets, with surface-treated pavements particularly vulnerable and rigid pavements more resilient. The framework provides TxDOT with scalable tools for district- and statewide prioritization, enabling identification of vulnerable assets, estimation of long-term costs, and integration of resilience into maintenance, rehabilitation, and investment strategies. By incorporating these methods into the 2026 Transportation Asset Management Plan, TxDOT can systematically embed resilience into planning, design, and decision-making processes.

#### CONTENTS

Introduction -- Flood Exposure and Risk -- Effects of Flooding on Pavement Life Cycles and Maintenance -- Flooding Risks for Bridges -- Adaptation Strategies -- Asset Risk and Resilience Assessment Framework -- Proxy Indicators -- Project Outcome Incorporation into 2026 TAMP -- Conclusions and Recommendations -- References -- Appendix A: Moisture Effects on Pavement Life Cycles Literature Review -- Appendix B: R&R Framework Details -- Appendix C: R&R Framework Case Studies

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### **Item 13. Traffic Control Device Analysis, Testing, and Evaluation** **Program: FY 2025 Activities**

*TEXAS A & M TRANSPORTATION INSTITUTE*  
*TTI 7198-2 | 2025*

Traffic control devices are a primary means of communicating highway information to road users and play a key role in highway automation. The design, application, and maintenance of traffic control devices are under constant transformation as new technologies, methodologies, and policies are introduced. In addition, vehicle technologies and the roadway infrastructure industry are rapidly evolving, spurred by technology advancements, customer demand, changes in the vehicle fleet, and changes in national and state policies. This project provides the Texas Department of Transportation with a mechanism to conduct high-priority, limited-scope evaluations of issues related to traffic control devices. Researchers conducted five activities during the 2025 fiscal year. Two of which were considered internal in nature, so those findings are not included herein. The remaining activities are ongoing and will be documented in future reports, as deemed appropriate. Research activities included in this report are: [1] Evaluation of driveway assistance devices in lane closures on two-lane, two-way roads. [2] Evaluation of motorist understanding of wait time display options for portable traffic signals.

#### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Evaluation of Driveway Assistance Devices
- Chapter 3. Driver Understanding and Preferences of Wait Time Displays on Portable Traffic Signals

This report is available for free download (46 pages, 3.6 MB):  
<https://library.ctr.utexas.edu/hostedpdfs/tti/0-7198-r2.pdf>

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### **Item 14. Synthesis: Commercial Air-Coupled Ground Penetrating Radar Systems to be Used for Pavement Evaluations in Texas**

*UNIVERSITY OF TEXAS AT ARLINGTON. DEPARTMENT OF CIVIL ENGINEERING*  
*UTA 7217-1 | 2025*

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This study examines the potential of air-coupled Ground Penetrating Radar (AC-GPR) systems to overcome limitations in the Texas Department of Transportation's (TxDOT) current pavement evaluation practices. The research integrates a comprehensive literature review, a statewide survey of TxDOT districts on GPR usage and barriers, and a technical assessment of commercially available AC-GPR platforms, including systems from GSSI, Kontur, IDS GeoRadar, and ImpulseRadar. Evaluation criteria included operational features, frequency ranges, data formats, and compatibility with TxDOT's PavCheck software. Findings indicate that the GSSI RoadScan system offers the most practical solution for near-term implementation due to its widespread adoption and training support, though proprietary data conversion is required for PavCheck integration. Recommendations include deploying the GSSI 27GHz horn antenna and SIR30 control unit, alongside modernizing PavCheck to ensure future compatibility. The study also identifies opportunities for advancing pavement monitoring through 3D GPR technologies and AI-assisted data processing, aiming to improve efficiency and support long-term infrastructure management.

### CONTENTS

Literature Review to Condense Current Practices and Significant Findings -- Interview Preparation Usage Requirements and Purposes of the Current GPR System -- Investigating GPR Equipment and Software -- Preliminary Analysis and Review of Available GPR -- Investigating Data Formats of the New Commercial GPR System for PavCheck -- Final Recommendation for New GPR System -- References -- Appendix A: Results of Survey of TxDOT Districts

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## Item 15. Development and Evaluation of Roadside Safety Systems for Motorcyclists—FY25

TEXAS A & M TRANSPORTATION INSTITUTE

TTI 9-1531-4 | 2025

Motorcycle fatalities have continued to rise in the United States over the past decade. The design of roadways and roadside safety hardware often neglects consideration for the safety of motorcycle road users. Under fiscal year 2025 of TPF-5(482), two research tasks were prioritized for evaluation and consideration of motorcycle safety. The first research task evaluated four roadway design elements and their effect on motorcycle safety. This consisted of evaluating raised crosswalks, speed bumps, vertical drop-offs, and roundabouts using an exploratory analysis in BikeSim. Computer simulations were performed to evaluate the potential for loss of motorcycle vehicle stability when engaging these roadway design elements in different conditions and scenarios. Interaction with these roadway design elements with low roadway friction values was found to be the primary source of loss of motorcycle vehicle stability. The

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second research task developed and evaluated two design concepts for terminating a rubrail element in a motorcycle-friendly guardrail system. Both design concepts were modeled for finite element analysis and evaluated through computer simulations. Manual for Assessing Safety Hardware (MASH) Test 3-10 and 3-11 computer simulations were performed to evaluate the performance of the design concepts according to MASH Test Level 3. Both systems were found to indicate satisfactory crashworthy performance in the computer simulations.

### CONTENTS

- Chapter 1. Introduction
- Chapter 2. Geometric Roadway Design Effects on Motorcycle Safety
- Chapter 3. Evaluation of Motorcycle Rubrail Termination
- Chapter 4. Summary and Recommendations

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