



Research Digest

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Item 1

Evaluation of Hydraulic Effects of Culvert Safety End Treatments

CENTER FOR TRANSPORTATION RESEARCH

CTR 2109-2 • 2006

Safety end treatments are installed on new and existing culverts to protect vehicular traffic if the vehicle should leave the roadway. Backwater effects associated with end treatment designs used by the Texas Department of Transportation have not been measured previously. Such measurements are provided through the hydraulic modeling program reported upon. Backwater effects are represented through minor loss coefficients (K_m), which are found to be small with a representative value $K_m = 0.021$ for all culvert end configurations investigated. Performance curves and coefficients are also presented for these different end configurations, which supplement results presented in 0-2109-1.

Full-text PDF of this report is available for free download at
http://www.utexas.edu/research/ctr/pdf_reports/0_2109_2.pdf

Item 2

Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration: A Literature Review

CENTER FOR TRANSPORTATION RESEARCH

CTR 4069-1 • 2006

This report describes part of the work associated with Texas Department of Transportation Project 0-4069 ("Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration"). The Texas Department of Transportation is interested in developing techniques for mitigating or remediating premature concrete deterioration due to alkali silica reaction (ASR), delayed ettringite formation (DEF), or both, in order to extend the life of potentially affected structures. The parts of Project 0-4069 reported here consist of: a literature search for mitigation or remediation techniques; fabrication of concrete specimens intentionally susceptible to premature deterioration; and the application and monitoring of the mitigation techniques using laboratory testing and acoustic emission (AE) procedures. Specimens were exposed to three series of environmental conditions: an indoor series; an outdoor series; and a wet/dry series. Expansion and internal relative humidity were measured to determine the efficacy of the mitigation techniques at reducing expansion from premature concrete deterioration. Based on the test results, recommendations are made for choosing mitigation treatments now, and for additional research.

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http://www.utexas.edu/research/ctr/pdf_reports/0_4069_1.pdf



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Item 3

Anchorage Requirements for Grouted Vertical-Duct Connectors in Precast Bent Cap Systems
CENTER FOR TRANSPORTATION RESEARCH
CTR 4176-1 • 2006

Bridge projects constructed in Texas that utilize precast bent caps typically employ grouted vertical ducts in the cap-to-column connections. This type of connection is preferred due to the simple geometry and because the volume of grout needed to complete the connections is minimized. A number of questions related to the sensitivity of the behavior of the grouted vertical-duct connectors to design parameters were identified during the design and construction of these bridges. Thirty-two, large-scale pullout tests of connectors grouted in galvanized steel and plastic ducts were conducted to investigate the response of this type of connector. The results indicate that the tensile capacity is sensitive to the type of duct, the embedded length of the connector, the number of connectors tested simultaneously in tension, and the placement of the connector within the duct. However, the results were not sensitive to epoxy coating on the connector or to the presence of spiral transverse reinforcement around the group of connectors. Design equations are proposed for the minimum embedded length of all connectors to satisfy serviceability concerns and for the development length necessary to resist the calculated tensile stresses in the connectors under the design load combinations.

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http://www.utexas.edu/research/ctr/pdf_reports/0_4176_1.pdf

Item 4

Performance Assessment by Using Nondestructive Testing
CENTER FOR TRANSPORTATION RESEARCH
CTR 4185-3 • 2006

This project was conducted to determine the correlation of field performance to Hamburg Wheel Tracking Device (HWTD) testing results. HWTD measures the combined effects of rutting and moisture damage by rolling a steel wheel across the surface of an asphalt concrete specimen that is immersed in hot water. The test results from this laboratory equipment have been promising in regard to evaluating the moisture susceptibility of hot mix asphalt mixtures. While there is some information on the relationship between the laboratory results from this test and the field performance, it is quite limited. This 5-year research project will be an important step in validating the test and ensuring that the test results could be reliably used to predict performance. Three designs (Superpave, CMHB-C, and Type C) and three aggregate sources (siliceous gravel, sandstone, and quartzite) were used for this study. The test sections including nine different mixture designs were constructed on IH-20 in Harrison County to observe the performance of the overlays under real traffic conditions. Field performance will be observed through visual pavement condition surveys and nondestructive tests for four years. This research report summarizes the nondestructive test results and visual pavement condition surveys in the third year of this study.

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http://www.utexas.edu/research/ctr/pdf_reports/0_4185_3.pdf



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Item 5

Pavement Performance Evaluation By Using Field Data

CENTER FOR TRANSPORTATION RESEARCH

CTR 4185-4 • 2006

This project was conducted to determine the correlation of field performance to Hamburg Wheel Tracking Device (HWTD) testing results. The HWTD measures the combined effects of rutting and moisture damage by rolling a steel wheel across the surface of an asphalt concrete specimen that is immersed in hot water. The test results from this laboratory equipment have been promising in regard to evaluating the moisture susceptibility of hot mix asphalt mixtures. This five-year research project will be an important step in validating the test and ensuring that the test results could be used reliably to predict performance. Three designs (Superpave, CMHB-C, and Type C) and three aggregate sources (siliceous gravel, sandstone, and quartzite) were used for this study. The test sections, including nine different mixture designs, were constructed on IH 20 in Harrison County to observe the performance of the overlays under real traffic conditions. Field performance will be observed through visual pavement condition surveys and nondestructive tests for four years. This research report summarizes the nondestructive test results and visual pavement condition surveys in the fourth year of this study.

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Item 6

Design for Shear in Reinforced Concrete Using Strut-and-Tie Models

CENTER FOR TRANSPORTATION RESEARCH

CTR 4371-2 • 2006

The design of reinforced concrete members for shear was studied. Both strut-and-tie models (STM) and sectional methods were examined. Initially, the response of isolated struts was observed. Various layout of reinforcement were used within the isolated struts. Three series of deep beam tests were also conducted. The first series was used to examine the effects of load distribution (uniform or concentrated) and distribution of shear reinforcement (horizontal and vertical) on shear strength of deep beams. The effects of beam width and shear span-to-depth ratio on shear strength were studied using the second series of beam tests. In the final series, the effects of load distribution on specimens without shear reinforcement were observed. A database of approximately 1,200 experimental results was compiled. The database, along with the experimental program, was used to evaluate the levels of conservatism of North American STM code provisions as well as sectional design provisions. A new design procedure was developed to improve the safety of STM design procedures. Along with the new procedures, an expression was created to determine the necessary amount of reinforcement within a bottle-shaped strut. Finally, recommendations to improve the conservatism of sectional design provisions were developed.

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Item 7

Bridge Slab Behavior at Expansion Joints

CENTER FOR TRANSPORTATION RESEARCH

CTR 4418-1 • 2006

The primary objective of this research study was to evaluate the behavior and capacity of the IBTS and alternate 8 in. UTSE (Uniform Thickness Slab End) details at expansion joints, especially on skewed ends of bridge slabs. The two full-scale CIP (cast-in-place) specimens, 0o and 45o skews, were constructed to test the effect of skew on the IBTS and UTSE details. Test results showed that at design load levels, skew had no significant effect on the behavior of the two details. All test areas failed in shear, predominantly punching shear. The UTSE details failed at slightly lower load levels than the IBTS detail due to a 2 in. difference in section depth. However, both details had ultimate capacities at loads well above the design load levels. Another objective of the research study was to develop alternate details and investigate construction issues of those alternate details. Since the UTSE details performed satisfactorily at design and ultimate load levels, an alternate detail using the stay-in-place PC (precast) panels in the end regions was developed and tested. The PCPE (Precast Panel End) details would eliminate special formwork construction and reduce safety concerns associated with such formwork construction at heights. The full-scale PCPE specimen, 0o skew, was built since panels cannot be easily incorporated in bridge decks with a skewed end. In addition to the behavior and capacity of PCPE details, the effects of armor joints (AJ) and sealed expansion joints (SEJ) on slab ends at design and ultimate loads were investigated. Test results showed that the PCPE details performed similar to the IBTS and UTSE details at design and failure load levels. The PC panel details failed at loads lower than the IBTS details, and the AJ and SEJ increased ultimate capacity by 20 to 25% when compared to PCPE without AJ or SEJ.

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Item 8

Driver Responses to Urban Freeway Information Loads

CENTER FOR TRANSPORTATION RESEARCH

CTR 4621-2 • 2006

Traffic control devices are intended to convey information to drivers enabling them to safely and efficiently negotiate highway systems. In addition to information from control devices, drivers gather information from surrounding traffic streams, highway geometry, the vehicle itself, and many off-road visual information sources. Driving on urban freeways demands a high level of driver attention to many, sometimes competing, information sources, and the driver must quickly filter these data-interpreting that which is important- and continually prepare for the next elements in the information stream. Drivers have finite abilities to receive, filter, and process information per time unit, and if the information flow reaches or exceeds typical human limits, driver stress levels may increase and important bits of information may be missed completely or misinterpreted. Relationships between information flow, driver stress, driver performance and accident experience have been hypothesized. This study classifies urban freeways in Dallas, Houston, and San Antonio, Texas, regarding the intensity of information flow or information load presented to drivers. Crash statistics for 1999, 2000, and 2001 are compared to information load rates and significant correlations are identified. Test drivers experience each of the twenty-seven information load levels identified for the freeways in the three Texas cities as they negotiate selected driving routes. A portable data acquisition system records the driver's field of view, vehicle trajectory data, driver electrocardiogram, and eye movements as the drivers experience the real world information flow situations. Correlations between driver stress level, characterized by heart rate or electrocardiogram wave form and information load, are identified. Thresholds for minimum and maximum desirable numbers of traffic control signs per unit distance are developed for freeways having two, three or four, and five or more lanes per direction. A methodology for classifying urban freeways regarding information loads presented to drivers is described.

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Item 9

Application of Credit-Based Congestion Pricing in Texas: Operational Considerations and Impacts

CENTER FOR TRANSPORTATION RESEARCH

CTR 4634-1 • 2006

Credit-based congestion pricing (CBCP) is a novel strategy that seeks to overcome the negative equity impacts of congestion pricing (CP) by allocating monthly budgets to eligible travelers to spend on congestion tolls. Previous CBCP studies have surveyed public opinion and examined the traffic and travel-welfare impacts of an Austin, Texas application. This work develops the policy further, examining expert opinions, predicting traffic impacts, estimating air-quality changes, and predicting system costs.

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Item 10

Development Of Mix Design And Testing Procedures For Cold Patching Mixtures

CENTER FOR TRANSPORTATION RESEARCH

CTR 4872-1 • 2006

The objective of this study is to address the use and performance of homemade and containerized patching maintenance mixtures for repairs in cold and wet weather. The Texas Department of Transportation (TxDOT) reported problems relating to the durability, workability, and shelf life of homemade patching mixtures under these conditions. TxDOT requires an improved mix design procedure to develop patching mixtures with a durability of at least 6 months that accounts for traffic volume. Various failure mechanisms pertaining to the use of cold patch mixtures were identified and current mix design, materials, performance evaluation, and field application procedures were assessed. Based on results from screening experiments, a preliminary mixture design procedure was developed. A laboratory experiment was developed to evaluate the performance of patching materials by investigating the influence of pertinent material characteristics, including gradation, aggregate type, binder viscosity and content, compaction temperature, curing time, and use of admixture. The materials selected for homemade mix design in the laboratory are consistent with those used by the Lubbock district in its homemade mix design. The Cold Patch Slump Test (CPST), a slump-based laboratory workability test, was developed to quantify workability for cold patch materials. It is an inexpensive and quick test and shows correlation between laboratory and field values. The Hamburg Wheel Tracking Device (HWTD) was used for stability testing on cold patch mix, which was first cured and then compacted at elevated temperatures. Indirect Tensile Strength (ITS) and stripping tests will be conducted on the homemade mixes. The initial field evaluation included six containerized medium-curing products, three homemade mixes made by district maintenance yards in the Lubbock district, and one commercially produced stockpile mix in Lufkin. The study area for the field evaluations is the Lubbock and Lufkin districts of TxDOT. The results of the field evaluation are still being collected and will be reported in the coming year. A preliminary evaluation of the effectiveness of various cold patching mix containers was also conducted and guidelines for further durability testing in the laboratory were developed. Full text PDF of this report is available for free download at

http://www.utexas.edu/research/ctr/pdf_reports/0_4872_1.pdf

Item 11

User Manual for the TxDOT Rigid Pavement Design and Analysis Web-Based Training Site

CENTER FOR TRANSPORTATION RESEARCH

CTR 5-1869-03-1 • 2006

This document is the user manual for an online training program accessible through the Internet. The website provides access to and training in the use of various computer programs used in the design and analysis of rigid pavement.

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http://www.utexas.edu/research/ctr/pdf_reports/5_1869_03_1.pdf



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Item 12

Rigid Pavement Design and Analysis Web-Based Training Site

CENTER FOR TRANSPORTATION RESEARCH

CTR 5-1869-03-P8 • 2006

This website offers training for six computer programs pertaining mainly to the design and analysis of rigid pavements. The programs are CRCP9, CRCP10, JRCP6, PavePro, RPLCCA, and TxPTS.

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http://www.utexas.edu/research/ctr/pdf_reports/5_1869_03_P8.pdf

Item 13

UIT Application During Fabrication

CENTER FOR TRANSPORTATION RESEARCH

CTR 5-4178-01-3 • 2006

Traffic signal mast arm baseplate connections are particularly susceptible to fatigue. The top of traffic signal mast arm welds experience fluctuating tensile stresses when wind and traffic gust loads cause the mast arm to oscillate. It has been postulated that UIT application to mast arm weld toes during the fabrication process will delay fatigue crack initiation. Successful UIT application during the fabrication process will extend fatigue lives of traffic signal mast arm welds in the field. Since mast arm welds are the weakest spot in the traffic signal structure, increased weld life translates into increased traffic signal life. Previous research claims that UIT is light, quiet, and easy to learn. Critical areas under scrutiny during UIT application at the fabrication plant are: time lost due to training workers, time lost during the UIT application, and efficiency of the treated poles. This report investigates the first two issues by documenting the application of UIT to fabricated mast arms at the TransAmerican Power Products facility.

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Item 14

Automatic Inspection of Pavement Cracking Distress

CENTER FOR TRANSPORTATION RESEARCH

CTR 5-4975-01-1 • 2006

This paper presents the image-processing algorithm customized for high-speed, real-time inspection of pavement cracking. In the algorithm, a pavement image is divided into grid cells of 8 x 8 pixels, and each cell is classified as a non-crack or crack cell using the grayscale information of the border pixels. Whether a crack cell can be regarded as a basic element (or seed) depends on its contrast to the neighboring cells. A number of crack seeds can be called a crack cluster if they fall on a linear string. A crack cluster corresponds to a dark strip in the original image that may or may not be a section of a real crack. Additional conditions to verify a crack cluster include the requirements in the contrast, width, and length of the strip. If verified crack clusters are oriented in similar directions, they will be joined to become one crack. Because many operations are performed on crack seeds rather than on the original image, crack detection can be executed simultaneously when the frame grabber is forming a new image, which permits a real-time, online pavement survey. The trial test results show good repeatability and accuracy when multiple surveys were conducted in different driving conditions.

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Item 15

Engineering Properties of Tire Bales for Soil Repairs and Embankment Construction

CENTER FOR TRANSPORTATION RESEARCH

CTR 5-9023-01-1 • 2006

This report summarizes the results of tasks conducted to characterize the properties of tire bales for use in limit equilibrium stability analyses. The test results indicate that the use of tire bales is a promising alternative for slope stabilization.

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Item 16

Planning for Container Growth Along the Houston Ship Channel and Other Texas Seaports: An Analysis of Corridor Improvement Initiatives for Intermodal Cargo

CENTER FOR TRANSPORTATION RESEARCH

CTR 5068-1 • 2006

This is a study of Texas port and rail infrastructure and its suitability for handling increased volumes of containers in the near future. The report is the latest in a series of studies performed by of the Center for Transportation Research for the Texas Department of Transportation. Four ports and their corresponding rail corridors are covered within the report. They are the Ports of Beaumont, Houston, Corpus Christi and Brownville. The report reviews recent actions taken by each of these ports in order to improve the efficiencies of container handling and/or the efficiencies of inland intermodal corridors. The researchers conclude that demographic and economic changes in Texas may lead to an intrastate diversification of container flows with more cargo ports handling inbound container shipments. Increasing energy prices and constraints on the trucking industry will create incentives for greater reliance on rail for intermodal movements, especially for out of state destinations.

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Item 17

Effective Message Design for Dynamic Message Signs

TEXAS TRANSPORTATION INSTITUTE

TTI 4023-5 • 2006

This report contains the findings of research on relevant issues for effective design and display of dynamic message sign (DMS) messages. Findings resulting from visits and interviews with staff at five Texas Department of Transportation (TxDOT) traffic management centers relative to display of DMS messages are presented. The development and documentation of message design decision logic flow charts are also presented. Details of the experimental design and findings of focus group and human factors laboratory studies address many DMS message design issues including incidents, roadwork, AMBER alerts, major catastrophes, planned special events, and inclement weather and environmental conditions. Discussion of the issues and the contents of the Dynamic Message Sign Message Design and Display Manual that was developed as part of this project are also presented.

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Item 18

Database of Sulfate Stabilization Projects in Texas

TEXAS TRANSPORTATION INSTITUTE

TTI 4240-4 • 2006

Highways in Texas are now constructed much more rapidly than they were 20 years ago. During this same time period, there has also been an increase in the number of pavement failures in Texas attributed to a phenomenon called sulfate-induced heave. As part of Research Project 0-4240, a database of pavement failures due to sulfate-induced heave problems was developed. The researchers traveled across the state in search of pavement failures due to sulfate stabilization problems with calcium-based stabilizers. All of the projects discussed in this report were verified by the researchers as being caused by sulfate-induced heave. This report details eight case studies located in nine counties spread across the state of Texas. Many failures that had previously been attributed to improper stabilization of expansive sub grades can now be classified as sulfate heave problems. Comments from the Texas Department of Transportation (TxDOT) inspectors and construction engineers like "roller coaster roads" and "diamonds sparkling on the hillside" were commonly applied to these areas. Geologic maps, available in a Geographic Information Systems (GIS) format, indicated the presence of sulfates on 75% of the projects discussed in this report. Two alternatives to lime and cement were evaluated on three soils containing sulfates in excess of 20,000 ppm. An acid stabilizer showed improvement in strength but did not reduce swell over the long term. A mixture of ground granulated blast furnace slag and lime increased strength and reduced swell in all high sulfate soils tested.

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

<http://tti.tamu.edu/documents/0-4240-4.pdf>

Item 19

Contract Negotiation Tools for Professional Services on Highway Projects

TEXAS TRANSPORTATION INSTITUTE

TTI 4297-1 • 2006

Increased use of professional services firms for engineering and related services created the need for tools and methods that can support and improve TxDOT negotiation of contracts and management of professional services firms. A data availability and applicability analysis identified a wide variety of types and sources of historical data that might be useful for developing and populating database tools. However, the lack of information in the specific interactions among existing data prevented full development of tools based on historical data. Work to develop tools for structuring cost proposals of professional services firms that can also facilitate proposal analysis by TxDOT personnel produced two prototype spreadsheet tools. Initial feedback and testing at a TxDOT district indicate that the tools can improve negotiations and provide the basis for the development of database tools. Additional development and training in tool use are recommended.

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Research Digest

Item 20

Design Procedure for Pavements on Expansive Soils: Volume 2

TEXAS TRANSPORTATION INSTITUTE

TTI 4518-1 Vol. 2 • 2006

Swelling and shrinkage of subgrade soils are critical factors contributing to increases in roughness and degradation of serviceability of highway pavements. Existing procedures for predicting swell are largely based on the potential vertical rise (PVR) procedure developed by McDowell in 1956. While the PVR procedure represents a major development in the design of pavements on expansive soils, instances of apparently over-conservative PVR predictions have led some designers to suggest revision or replacement of the existing procedure. This project reviews the basic assumptions of the existing PVR procedure and identifies the likely sources of the questionable predictions that have arisen in the past. An alternative procedure is presented that features rigorous modeling of both the moisture diffusion process that induces changes in suction within a soil mass and the deformations that occur in response to changes in suction. This alternative procedure includes provisions for measuring and/or estimating soil and environmental input parameters necessary for the predictions. A procedure for predicting the impact of soil deformations on pavement performance is also presented. The proposed procedure is applied to three study sections involving Texas roadways on expansive soils, and parametric studies are presented evaluating the effectiveness of various design measures including moisture barriers, lime treatment, and replacement of in situ sub-grade soils with "inert" soils.

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<http://tti.tamu.edu/documents/0-4518-1-V2.pdf>

Item 21

Water Quality Characteristics and Performance of Compost Filter Berms

TEXAS TRANSPORTATION INSTITUTE

TTI 4572-1 • 2006

The Texas Department of Transportation, in conjunction with the Texas Commission on Environmental Quality and the Environmental Protection Agency, commissioned a study to examine the water quality impacts of compost leachate constituents and structural integrity of unseeded compost filter berms, seeded compost filter berms, and compost/mulch filter socks. Wood mulch filter berms, straw bales, and silt fence were tested comparatively. Three compost types were tested: dairy manure, biosolids, and yard waste. The berms and filter sock material used a mixture of 50 percent compost and 50 percent wood chips. Studies were conducted with low velocity flows. Each of the alternatives was tested for two rounds consisting of three repetitions each round on both sand and clay soils. Results showed that the yard waste compost outperformed the dairy manure compost and biosolid compost in water quality characteristics and structural durability in performance. The berms that were seeded and left in place long term surpassed the unseeded berms in their ability to sustain overtopping and retain their structure.

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Research Digest

Item 22

Recommended Practices for Hurricane Evacuation Traffic Operations

TEXAS TRANSPORTATION INSTITUTE

TTI 4962-P2 • 2006

The Texas Department of Transportation (TxDOT) directed this research project to include development of traffic operations recommendations for hurricane evacuation. This was accomplished largely through reviews of "lessons learned" reports and interviews with staff members of departments of transportation of other states that border the Gulf of Mexico or the Atlantic Ocean and have experience conducting hurricane evacuations. Reviews of state hurricane evacuation plans and associated literature point to many similarities among these states in their approach to evacuations; e.g., most states have some form of contraflow freeway operations. Conversely, few states convert shoulders for evacuation lanes. This document describes findings from among agencies involved in traffic operations practices for hurricane evacuations and offers recommendations for hurricane evacuations in Texas.

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Item 23

Support for the Implementation of a Longitudinal Joint Density Specification for Hot-Mix Asphalt Concrete

TEXAS TRANSPORTATION INSTITUTE

TTI 5-1757-01-1 • 2006

Research project 0-1757 assessed the density of the longitudinal construction joint of many pavements in Texas and identified that a significant joint density problem existed, which justified the implementation of a joint density specification. This specification is now included as part of the Standard Specifications for Item 341 (Dense-Graded Hot-Mix Asphalt). To facilitate the implementation of the research and specification, the following objectives were included in this implementation project: - identify the most promising construction techniques aimed at achieving longitudinal joint density; - develop and conduct training seminars for the districts on construction of longitudinal joints and on the new TxDOT testing and specification requirements; - acquire non-nuclear density gauges; and - evaluate current longitudinal joint density criteria and the ability of contractors to meet the criteria. Project 0-1757, which provided the background supporting the need for a longitudinal joint density specification, reported densities near the unconfined edge averaging 6 to 7 lb per cubic foot below the densities taken at the center of the mat. Since the implementation of a joint density specification, a significant improvement in the longitudinal joint density has been observed. Data from some of the projects presented herein indicate a joint density of only 1.0 pcf (or less) below the density of the mat interior.

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