Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-06/5-1757-01-1		

4. Title and Subtitle	5. Report Date
SUPPORT FOR THE IMPLEMENTATION OF A LONGITUDINAL JOINT DENSITY SPECIFICATION FOR HOT-MIX ASPHALT CONCRETE	January 2006 Published May 2006
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Cindy K. Estakhri	Report 5-1757-01-1

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	11. Contract or Grant No. Project 5-1757-01-1

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin, Texas 78763-5080	Technical Report: January 2004 – March 2005
	14. Sponsoring Agency Code

15. Supplementary Notes

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Project Title: Support for the Implementation of Longitudinal Joint Density

URL: http://tti.tamu.edu/documents/5-1757-01-1.pdf

16. Abstract

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.

17. Key Words	18. Distribution Statement
Highway Construction, Hot-Mix Asphalt Concrete, Density, Longitudinal Construction Joint, Longitudinal Joint Density	No restrictions. This document is available to the public through NTIS: National Technical Information Service Springfield, Virginia 22161, http://www.ntis.gov

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	20	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

SUPPORT FOR THE IMPLEMENTATION OF A LONGITUDINAL JOINT DENSITY SPECIFICATION FOR HOT-MIX ASPHALT CONCRETE

by

Cindy K. Estakhri, P.E.
Associate Research Engineer
Texas Transportation Institute

Report 5-1757-01-1
Project 5-1757-01-1
Project Title: Support for the Implementation of Longitudinal Joint Density

Performed in Cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

January 2006

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. The researcher in charge of the project was Cindy Estakhri, P.E. (77583).

ACKNOWLEDGMENTS

Special thanks are given to the TxDOT project director, Magdy Mikhail, for providing technical guidance and assistance in the training workshops. Thanks also are given to the following TxDOT personnel who provided technical information: Cullen Pfeiffer of the San Antonio District; Ricky Walker and Chris Cunningham of the Lubbock District; Rene Soto of the Laredo District; Roger Ledbetter, Casey Brazeal and Brent Doddy of the Atlanta District; William Willeford of the Tyler District; Tom Dahl of the Brownwood District; and Tammy Hilbig of the Austin District. This project was completed in cooperation with TxDOT and FHWA.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

BACKGROUND AND OBJECTIVES

When placing hot-mix asphalt concrete (HMAC), paving the full width of the pavement in a single pass is usually impossible; therefore, most bituminous pavements contain longitudinal construction joints. These construction joints can often be inferior to the rest of the pavement and can eventually cause an otherwise sound pavement to deteriorate. Many pavement failures can be directly attributed to the infiltration of water into the pavement structure through the longitudinal construction joint. 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.

SUMMARY OF WORK PERFORMED

IDENTIFICATION OF PROMISING CONSTRUCTION TECHNIQUES

Texas Transportation Institute (TTI) engineers reviewed the literature and contacted experts to gather information on the most promising new construction techniques aimed at achieving longitudinal joint density. Several different longitudinal joint construction techniques were investigated:

- notched wedge joint;
- tapered joint;
- cutting wheel technique;
- joint adhesives; and
- echelon paving.

In addition, researchers identified sound compaction procedures for proper joint construction which was incorporated into the training seminars. There are 4 keys to constructing good longitudinal joint:

1. Proper compaction of unsupported edge of lane 1. A steel wheel roller should be used but if it is operated inside or at the unsupported edge of the pavement, the mix may move transversely which can cause a crack or a dip in the pavement. The proper location of the drum is to extend it over the unsupported edge of the pavement by about 6 inches. This will prevent any shear loading at the edge of the drum and, thus, any transverse movement of the mix.

2. Proper overlap of mix from lane 2 to lane 1. The amount of transverse overlap of mix from lane 2 onto lane 1 is critical in the construction of a durable joint. If an excessive amount of mix is placed over the edge of lane 2, it will have to be removed by raking or it will be crushed by the rollers. If not enough mix is placed over the edge of the first lane, a depression or dip will occur on the lane 2 side of the joint. The amount of transverse overlap needed is in the range of 1 to 1 ½ inches for proper longitudinal joint construction. In addition, when the mix from lane 2 is placed over the top of the compacted mix on lane 1, the mix needs to be high by the amount of compaction that will occur. Dense-graded mixes typically compact at a rate of ¼ inch per inch.

3. Raking the longitudinal joint. Longitudinal joints which are constructed properly with the correct amount of overlap should not be raked. When raking, the amount of mix needed at the joint is usually pushed into the hot mix on lane 2. By setting the rake down on the compacted mix of lane 1 and pushing the rake transversely into the mix at the joint, the mix is shoved on top of the hot mix on lane 2. This makes the mix too low on the lane 2 side of the joint. This will cause a low density on the lane 2 side.

4. Proper compaction of the longitudinal joint. Either the steel wheel or pneumatic roller should be positioned a short distance over the top of the joint from the hot side of the joint. For a rubber tired roller, the center of the outside tire should be placed directly over the top of the joint. This permits proper compaction of the mix at the joint as well as compaction of the mix on lane 2. For a steel wheel roller, the majority of the weight of the drum should be placed on the mix on lane 2 with only 6 inches or so of the width of the drum extending over the top of the joint and over the top of lane 1. This allows the roller to apply most of its weight to the new HMAC while still compacting the mix at the joint.

TRAINING SEMINARS

Training materials were prepared, which included a half-day presentation in addition to handout reference documents. Seminars were conducted in six TxDOT districts: Beaumont, Laredo, Childress, Odessa, San Antonio, and Bryan. Attendees included both TxDOT and contractor personnel. Topics covered in the class included the following:

- proper compaction of HMAC pavements, in general;
- sound construction practices for the longitudinal joint in HMAC;
- new and innovative techniques for improving the quality of longitudinal joints;
- longitudinal joint density specification;
- emerging technologies in measuring quality of asphalt pavement construction;
- Tex 207-F Part IV, Establishing Roller Patterns;
- Tex 207-F Part VII, Measuring Longitudinal Joint Density; and
- non-nuclear density gauges.

ACQUISITION OF NON-NUCLEAR DENSITY GAUGES

Ten Pavement Quality Indicators (PQI) and 10 calibration blocks were purchased by TTI and shipped to contacts at the following district offices: Abilene, Atlanta, Childress, El Paso, Laredo, Lubbock, Odessa, San Angelo, San Antonio, and Tyler. Prior to shipment, density measurements were made with all 10 gauges, and a statistical evaluation was performed to ensure that each gauge had an acceptable range of variability.

EVALUATION OF JOINT DENSITY SPECIFICATION CRITERIA

During this implementation project, projects were just beginning to be bid with TxDOT's new *2004 Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.* As a result, there were very few districts and contractors who had any experience at all with the new specification. A few districts had included the requirement as part of a special provision to some projects prior to publishing and implementation of the new 2004 specification. Construction data were collected from projects where the joint density specification was in effect, and these data are summarized in Tables 1 through 9.

Table 1 shows the data from a project on I 35 in the San Antonio District. This project was a stone-filled hot mix, and the contractor experienced several construction difficulties. About half of the 47 joint density measurements obtained failed the specification. These types of mixes are typically very harsh and difficult to compact, which was the case here.

Tables 2 and 3 are Type C Coarse Matrix High Binder (CMHB) mixes from the Lubbock District. Note that the mean density at the confined and/or unconfined edges for each project are 0.7 and 0.8 lb per cubic foot below the densities taken in the mat interior, respectively. While there are a few specification failures, this represents a significant improvement in the joint densities seen on many TxDOT paving projects prior to implementation of the joint density specification. Also of note is that both of these projects were built by the same paving contractor and are the same mixture type. Yet the second project (Table 3) that this contractor built shows fewer failures than the first project (Table 2) which may indicate that contractor experience with the specification requirement is a factor in being able to achieve the desired density at the joint.

Table 1. Density Data from the San Antonio District, Comal County, I 35, 25 mm Stone-Filled Hot-Mix Asphalt Pavement (February through April 2005).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	37	142.5 pcf	3.3 pcf	
Mat Density at Confined and Unconfined Edges	47	138.6 pcf	3.8 pcf	
Density Difference between Interior Mat and Confined or Unconfined Edge	47	4.5 pcf	3.7 pcf	23
Correlated Core Joint Densities	20	91.0 %	2.9 %	2

Table 2. Density Data from the Lubbock District, Hockley County, US 62, Type C Coarse Matrix High Binder Mix (June through August 2005).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	45	143.1 pcf	2.6 pcf	
Mat Density at Confined and Unconfined Edges	66	142.3 pcf	2.9 pcf	
Density Difference between Interior Mat and Confined or Unconfined Edge	66	1.3 pcf	1.3 pcf	4
Correlated Core Joint Densities	66	91.0 %	1.6 %	17

Table 3. Density Data from the Lubbock District, Lynn County, US 87, Type C Coarse Matrix High Binder Mix (July through October 2005).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	39	144.3 pcf	1.5 pcf	
Mat Density at Confined and Unconfined Edges	78	143.6 pcf	1.4 pcf	
Density Difference between Interior Mat and Confined or Unconfined Edge	78	0.8 pcf	1.0 pcf	0
Correlated Core Joint Densities	78	91.7 pcf	1.2 pcf	5

The Atlanta District recently used the joint density specification on US 259 on a Type B mix with excellent results, as shown in Table 4. The mean density at the unconfined edges were only 0.4 pcf below the mat density, and the confined edges were 1.0 pcf below the mat density. No joint density failures were observed.

Density results are shown on Type C mixes in Tables 5 through 8. The data for a project in Caldwell County (Table 5) indicate that the contractor had some problems meeting the density requirements at the unconfined edge but not on the confined edge. The data shown in Tables 6 and 7 show excellent joint densities were achieved on these two project in the Laredo District. The Laredo District has been incorporating the joint density requirement in some of their projects as a special specification for a few years. As a result, the contractors in the Laredo area may have more experience than in some of the other parts of the state. Data from the Tyler District (Table 8) show excellent joint densities.

A Type D mix from the Brownwood District shown in Table 9 also exhibits excellent longitudinal joint densities.

Table 4. Density Data from the Atlanta District, Dangerfield, US 259 S, Type B Hot Mix (March through April 2005).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	11	140.1 pcf	2.4 pcf	
Mat Density at Confined Edge	14	139.1 pcf	2.1 pcf	
Density Difference between Interior Mat and Confined Edge	14	1.0 pcf	1.4 pcf	0
Mat Density at Unconfined Edge	8	139.7 pcf	1.9 pcf	
Density Difference between Interior Mat and Unconfined Edge	8	0.4 pcf	0.8 pcf	0

Table 5. Density Data from the Austin District, Caldwell County, US 183, Type C Hot Mix (September through December 2004).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	52	145.8 pcf	3.6 pcf	
Mat Density at Confined Edge	38	144.1 pcf	4.8 pcf	
Density Difference between Interior Mat and Confined Edge	38	1.4 pcf	4.4 pcf	11
Mat Density at Unconfined Edge	21	140.6 pcf	4.8 pcf	
Density Difference between Interior Mat and Unconfined Edge	21	5.3 pcf	4.5 pcf	16

Table 6. Density Data from the Laredo District, Zavala County, US 57, Type C Hot Mix (December 2003 through January 2004).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	64	138.4 pcf	2.4 pcf	
Mat Density at Confined Edge	101	137.9 pcf	2.3 pcf	
Density Difference between Interior Mat and Confined Edge	101	0.7 pcf	1.2 pcf	0
Mat Density at Unconfined Edge	27	138.4 pcf	2.6 pcf	
Density Difference between Interior Mat and Unconfined Edge	27	0.7 pcf	1.3 pcf	0

Table 7. Density Data from the Laredo District, Zavala County, US 277, Type C (January through February 2004).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	60	135.7 pcf	3.1 pcf	
Mat Density at Confined Edge	95	134.4 pcf	3.2 pcf	
Density Difference between Interior Mat and Confined Edge	95	1.0 pcf	1.5 pcf	1
Mat Density at Unconfined Edge	25	135.6 pcf	2.3 pcf	
Density Difference between Interior Mat and Unconfined Edge	25	1.0 pcf	1.4 pcf	0

Table 8. Density Data from the Tyler District, Smith County, SH 155, Type C (August through September 2005).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	33	143.4 pcf	0.8 pcf	
Mat Density at Confined Edge	25	143.1 pcf	0.9 pcf	
Density Difference between Interior Mat and Confined Edge	25	0.3 pcf	0.8 pcf	0
Mat Density at Unconfined Edge	32	142.4 pcf	1.3 pcf	
Density Difference between Interior Mat and Unconfined Edge	33	1.0 pcf	1.3 pcf	1
Correlated Core Joint Densities	44	94.0 pcf	1.0 pcf	0

Table 9. Density Data from the Brownwood District, Mills County, Loop 323, Type D (November through December 2005).

Density Measurement	Sample Size	Mean	Std. Dev.	Number of Joint Density Specification Failures
Interior Mat Density	16	147.6 pcf	1.1 pcf	
Mat Density at Confined and Unconfined Edges	20	146.0 pcf	0.8 pcf	
Density Difference between Interior Mat and Confined or Unconfined Edge	20	1.5 pcf	0.7 pcf	0

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- In research project 0-1757, which provided the background supporting the need for a longitudinal joint density specification, researchers 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, the data presented in Tables 1 through 9 of different mixes around the state indicate that the new specification has resulted in a significant improvement in the longitudinal joint density. Some of the projects here indicate a joint density of only 1.0 lb per cubic foot (or less) below the density of the mat interior.
- During this implementation project, projects were just beginning to be bid with the new specification, so district and contractor experience with the specification is limited at this time.
- Preliminary information indicates that once contractors become familiar with the new specification requirement, compliance with the existing criteria is achievable.

SPECIFICATION RECOMMENDATION

The current TxDOT Specification Item 341.4 addresses the longitudinal joint density requirements as follows:

(3) Longitudinal Joint Density

(a) ***Informational Tests****. While establishing the rolling pattern, perform joint density evaluations and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern if needed to achieve the desired joint density. Perform additional joint density evaluations at least once per sublot unless otherwise directed.*

(b) ***Record Tests.*** *For each sublot, perform a joint density evaluation at each pavement edge that is or will become a longitudinal joint. Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results, on Department forms, to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.*

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if 2 consecutive evaluations fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Based on the data presented herein, no changes to the specification are recommended at this time. Preliminary data as presented herein indicate that contractors should generally be able to comply with the specification.