FORENSIC INVESTIGATION REPORT ON THE LTPP TEXAS SPS-5 PROJECT

Submitted by Fugro Consultants, Inc.
FHWA-LTPP SPS–5 PROJECT 48A500
US 175 Eastbound, Kaufman County, Texas
Date Prepared: July 2009

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Executive Summary

As part of the Long Term Pavement Performance (LTPP) studies, Specific Pavement Study Experiment 5 (SPS-5) was designed to examine the behavior of Asphalt Concrete (AC) overlays of AC pavements with varying traffic, climate, pre-overlay treatment, and overlay thickness. The SPS-5 test sections on US-175 near Kaufman, Texas were constructed in 1991 for this study. Analysis of material tests and field performance data from the SPS-5 sections provide opportunities to quantify the effects of each of the parameters mentioned.

In an effort to maximize the benefits of the LTPP SPS experiments, LTPP decided to conduct forensic investigations at selected test locations. The Kaufman, Texas location was chosen to investigate why the SPS-5 test sections outperformed the surrounding pavements. The forensic investigation focused mainly on reflection cracking and rutting concerns. Conclusions and observations are as follows:

1. The performance of the test sections overlaid with Recycled Asphalt Pavement (RAP) material exceeded expectations. The following factors are believed to have contributed to the excellent crack resistance of the mixtures placed: (1) high asphalt content, (2) acceptable in-place density, and (3) high quality aggregates. Aggregates utilized in the SPS-5 project for overlays were from an igneous source that has low absorption. As validated by the Hamburg and the Overlay test results, mixtures produced with this type of aggregate are less prone to cracking and rutting.

2. Although both types of materials demonstrated excellent performance, field performance data demonstrates that sections with virgin mixture overlay outperformed the sections overlaid with RAP. The laboratory overlay test results correlated well with the field performance data. Cores from the virgin AC sections had significantly higher number of cycles to failure than those from RAP sections.

3. For sections of thin and thick overlay of both virgin and RAP mixtures, milled sections showed less cracks than those without surface preparation. Longitudinal non-wheel path cracks reflected in non-milled sections of thick virgin overlay mixture

was self-healed the successive year. The section that was milled prior to overlay did not show significant crack reflection during the 17 years service life.

4. Thick overlay sections of both virgin and RAP mixture showed high resistance to transverse cracking when compared to thin sections. Sections with virgin mixtures exhibited less longitudinal cracks when compared to RAP mixtures, for both thin and thick overlays.

5. New longitudinal cracks originating on the surface layer were noted in thick overlay sections of both virgin and RAP mixtures. Sections with thin RAP mixture overlay showed more top-down longitudinal cracks when compared to sections with thin virgin overlay mixtures.

6. In terms of IRI, thicker virgin overlay sections performed better compared to all other sections. Sections with RAP mixture overlay showed improved IRI following the rehabilitation. Performance of the RAP mixture overlay reduced drastically after 7-10 years of service life when compared to the sections with virgin mixture overlay.

7. Falling Weight Deflectometer (FWD) measurements indicated an increase in structural capacity for all sections following the rehabilitation treatment in 1991. The thicker overlay sections showed less deflection in milled and non-milled sections of both RAP and virgin mixtures.

8. After 17 years of service, the virgin overlay mixes showed a maximum rut depth of 0.47 inches. Sections with RAP mixture overlay showed half the amount of rutting as in virgin overlays. For both virgin and RAP mixtures, all measurable rutting appears to have occurred in the wearing surface of HMA overlay. Studies indicated that HMA overlay thickness does not have a systematic effect on rut depth.

9. Laboratory test results of AC layer mixture properties of SPS-5 test sections reveal that high quality mixtures helped bridge over cracks in the existing pavement. In addition, high-density mixtures may have prevented excessive oxidation of the binder.

CHAPTER 1
FORENSIC INVESTIGATION

1.1 Introduction

A forensic investigation is the process by which a forensic engineering team gathers all necessary information to explain the probable causes of early failure in cases of under-performance, or reasons for extended life in cases of high performance. Pavement forensic investigations have become more popular in recent years, as billions of tax dollars are being spent each year to maintain the nation's huge investment in pavement facilities. Understanding the underlying reasons why pavements perform better or worse than expected can help the pavement industry meet expectations more reliably. As the industry faces tougher expectations for accountability, it is expected that forensic investigations will be conducted more frequently. These investigations provide information that the industry needs to improve.

1.2 LTPP Pavement Forensic Investigation Frame Work

One of the primary goals of Long Term Pavement Performance (LTPP) study is to improve pavement technology by understanding the reasons for performance or non-performance of a pavement structure. Pavement forensic investigation is an inevitable part of achieving this objective. LTPP has provided a framework for forensic investigations to promote consistency and uniformity within the LTPP forensic investigation program. Since LTPP sections have distinctive characteristics, a standard plan would not be applicable to all LTPP test sections. Hence, the framework was intended to help tailor an investigation plan for each candidate project. The three main components of the framework are **1) recommendations for investigation, 2) development of investigation plan and 3) implementation.** Recommendations for investigations include assembling a forensic team to assess the candidacy of the test section based on required data availability, willingness of the highway agency and cost considerations. The framework details the types of pavement investigation that should be considered depending on the pavement type (asphalt or PCC). The investigations recommended include collecting cores at cracks, trenches at rutted areas and drainage evaluation for flexible asphalt pavements. FWD, Ground Penetrating Radar (GPR), Spectral Analysis of Surface Waves (SASW), and Dipstick® measurements are recommended regardless of pavement type, to provide supplementary data for investigation.

So far pavement forensic investigations have been carried out on LTPP test sections to study the reasons for premature pavement failure. At some project locations, test sections have performed much better than expected compared to surrounding pavements. One such case is the SPS-5 project in Kaufman County near Dallas, Texas. This project was intended to study the most common asphalt rehabilitation techniques used by state highway agencies, and received great attention since it performed much better than expected. Even after 17 years of service, all SPS-5 sections showed excellent performance with reduced reflective cracking. Hence, the Texas SPS-5 project was selected for a more detailed forensic investigation.

CHAPTER 2
TEXAS SPS-5 FORENSIC INVESTIGATION

2.1 Background

The Texas SPS-5 project is on east bound US-175, a moderately traveled highway, located near Crandall, Texas. Project location detail is shown in Figure 1. The LTPP SPS-5 experiment was designed to examine the effects of varying traffic, climate, pre-overlay treatment, and overlay thickness on asphalt overlay performance. The rehabilitation was completed in1991, and includes surface preparation (2 inches milling and non-milling), type of asphalt overlay (virgin and recycled), and overlay thickness (2-inches and 5-inches). The layout of each section in the field and the AC layer thickness with treatments applied are detailed in Figure 2.

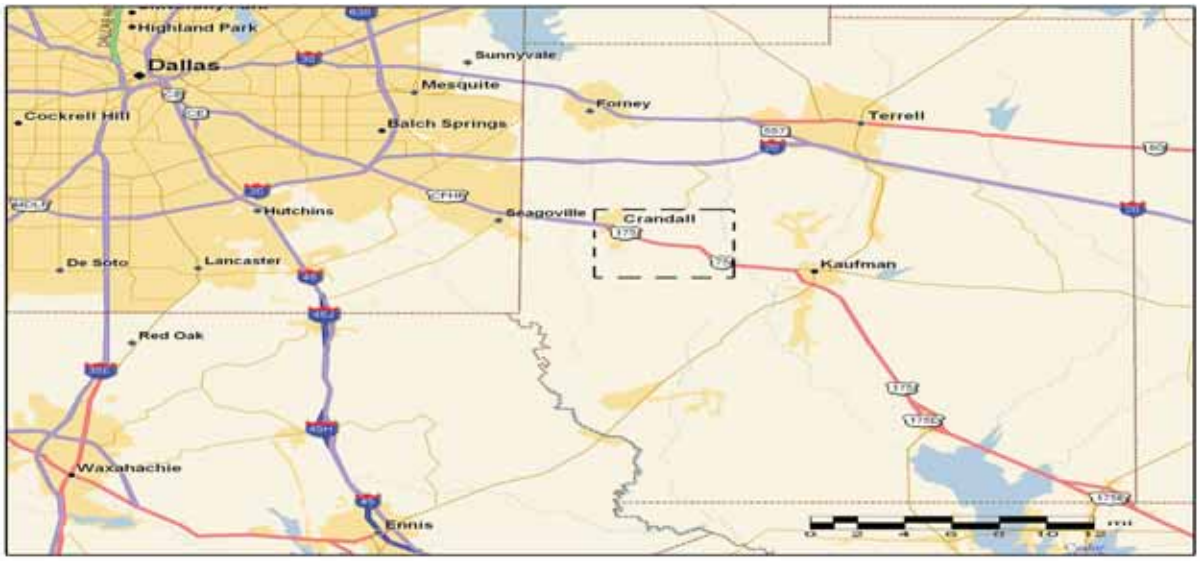


Figure 1: Project Location Details

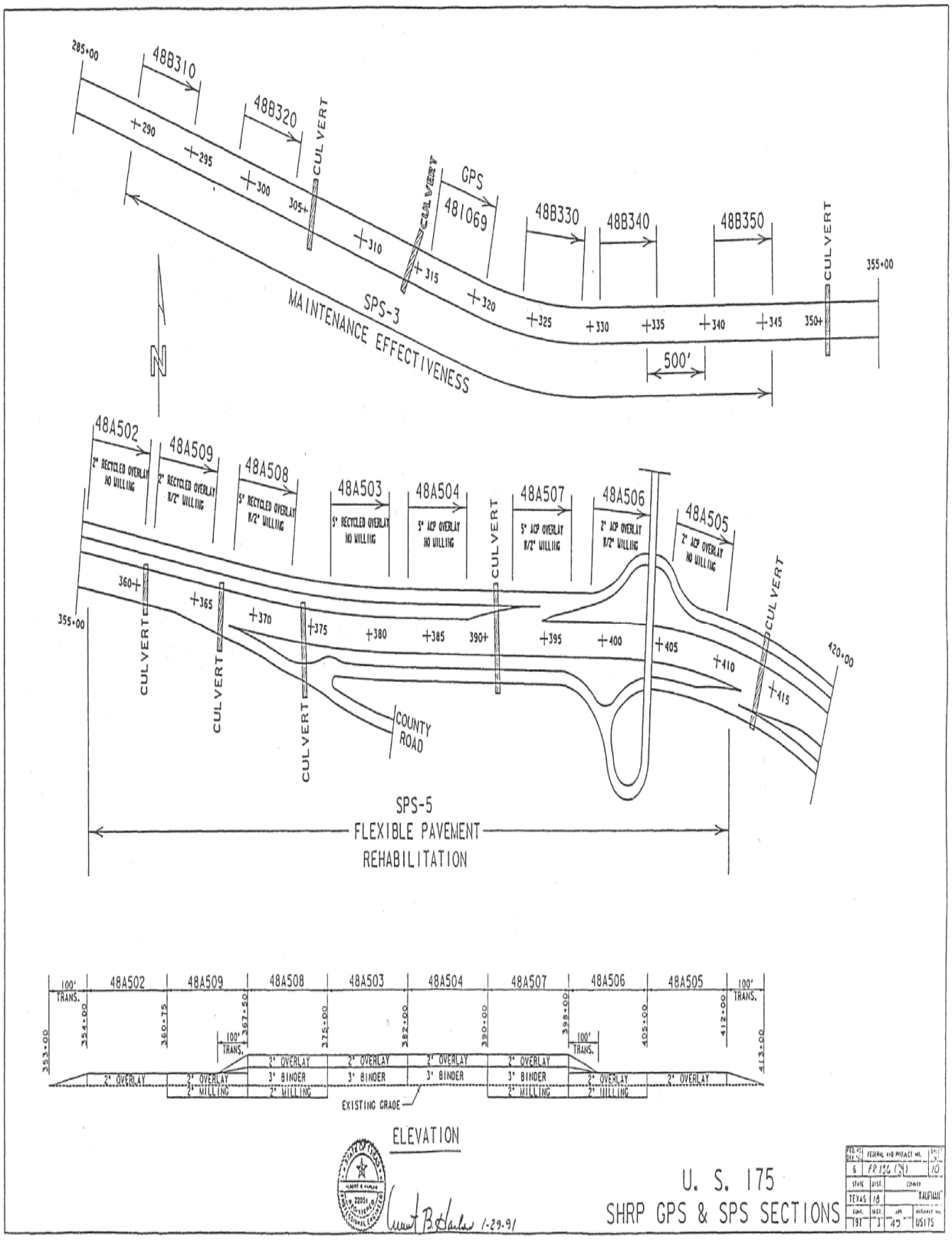


Figure 2: Layout of the 8 test sections and the treatments applied

Per Texas Department of Transportation (TxDOT) traffic data, the Average Daily Traffic (ADT) for US-175 in 2007 was 33,990 vehicles. The pavement structure below the asphalt layer consists of 12 inches of lime-stabilized base and 18 inches of lime-stabilized subgrade. The pavement age for US 175 sections is approximately 22 years.

The percent of RAP used in this project was fixed at 35%. The remaining 65% virgin AC used in the mixture had a softer grade (AC-5) binder. An AC-10 binder with 3% latex modifier was used in overlay sections with virgin mixture. Mix design data shows that Traprock and Granite screenings were used for both sections of Type C mix with 4.5 % asphalt in RAP sections and Type B mix with 5.2% asphalt in virgin sections. Anti-stripping agents Perma Tac Plus and Adhere HP Plus were added to Type C and Type B mixes, respectively. Milled sections were leveled with the respective binder course before the planned 2 inches and 5 inches overlay was applied. Hence, the total overlay thickness for the milled thin overlay and the thick overlay sections were 4 inches and 7 inches respectively. Surface preparation, mixture type, and treatments applied for each section are detailed in Table 1.

Table 1: Details of Surface Preparation, Mixture Type and Treatment of Each Section

Section No.	Treatment	Preparation	Mixture Type
48 A 502	2.2 " Overlay	No Milling	RAP
48 A 503	2.1 " overlay + 3" Binder	No Milling	RAP
48 A 504	2.2 " overlay + 3" Binder	No Milling	Virgin
48 A 505	2" Overlay	No Milling	Virgin
48 A 506	2.3" Overlay + (2”binder to cover for milling)	2" Milling	Virgin
48 A 507	2" overlay + 3" Binder + (2”binder to cover for milling)	2" Milling	Virgin
48 A 508	2.1 " overlay + 3" Binder + (2”binder to cover for milling)	2" Milling	RAP
48 A 509	2.2 " Overlay + (2”binder to cover for milling)	2" Milling	RAP

2.2 Investigation Objectives

The objectives of this investigation were established considering the excellent performance of the SPS-5 sections of both RAP and virgin mixture type as listed below:

- Investigate the reasons for better than expected overlay performance,
- Evaluate pavement performance over the years and the progress of reflected cracks with respect to treatment and distress type,
- Identify crack patterns associated with major types of distresses if any,
- Characterize the mixture and material types that helped reduce distresses with respect to the treatment applied, and
- Recommend the best rehabilitation treatments for similar projects based on this study.

2.3 Data Assessment

Data collection for the SPS-5 project in TX has periodically been done as a part of the LTPP study. A continuous record of distress, FWD, and profile measurement data from the year of rehabilitation (1991) are available for this project. Apart from this, data was collected from these sections in 2007 as a part of LTPP Material Action Plan (MAP). This data was collected to fill gaps in materials test data, aging study and for the Materials Reference Library. Time series plots of this data were prepared to evaluate the conditions and to prepare a detailed forensic investigation plan.

2.4 Investigation Plan

The LTPP forensic investigation framework recommends a detailed investigation including a distress mechanism investigation, and collection of “missing” data. The forensic investigation plan for the Texas SPS-5 project was tailored to address only the distress mechanism investigation, as the missing data collection was already done in 2007. Major distress types were identified by comparing distresses before and after rehabilitation treatment. Following the LTPP forensic investigation guidelines, a distress investigation matrix was prepared, and is provided in Table 2. For each section, a detailed plan identifying the distress type and core location was prepared to assist the crack study, which is provided in Appendix A. To supplement the material testing and characterization investigation, a detailed laboratory-testing plan was prepared. Non-destructive testing including FWD measurements, longitudinal profile measurements, manual distress survey and Dipstick®

data were also planned for this study. Trenches at rut areas were added to supplement the investigative data collection process.

Table 2. Distress Mechanism Investigation Matrix

Structure Type	Distress	Action	Location	Purpose	Laboratory Tests
AC, AC/AC	Fatigue Cracking	Core	Within and outside Area	Visual determination of crack origin	Density, Air voids, Asphalt content, Mix properties, Asphalt properties, Overlay test, Hamburg Test, and Rut measurements.
	Longitudinal Cracking (Wheel Path)	Core	At crack and within 0.5 m of the crack	Visual determination of crack origin	
	Longitudinal Cracking (Non Wheel Path)	Core	At crack and within 0.5 m of the crack	Visual determination of crack origin	
	Transverse Cracking	Core	At crack and within 0.5 m of the crack	Visual determination of crack origin	

2.5 Implementation

The Federal Highway Administration (FHWA) LTPP team, together with an investigation team from TxDOT and Texas Transportation Institute (TTI) reviewed the proposed forensic investigation plan for cost and program benefits. With the enthusiasm and support of each agency, the final investigation plan was put forward. The plan clearly analyzed major distresses in each section, identified the location of each core, selected the methods and protocols for lab testing, indicated the type of data required to be collected, and specified the agency responsible for each activity. The list of field activities and the agency responsible for each activity are listed in Table 3.

Table 3. Activities Performed and Agency Responsible

ROLES AND RESPONSIBILITIES	
Responsible Organization	**Activities**
Texas Department of Transportation	Traffic Control
	Coring 4" diameter cores
	Arrange water for coring activity
	Patching core holes
	Trenches for rut measurement
	Laboratory Testing
Texas Transportation Institute	Hamburg Test
	Overlay Testing
Fugro Consultants Inc, Austin, TX	Forensic Investigation Plan
	Coordination of activities
	Longitudinal Pavement Profile Measurement
	Deflection Testing (FWD)
	Manual Distress Survey
	Coring 12" diameter cores
	Transportation of cores for laboratory testing
FHWA - LTPP	Overall responsibility of LTPP testing operations

Non-destructive tests performed included Manual Pavement Distress Surveys, Dipstick® transverse pavement profile measurements, Profiler longitudinal pavement profile measurements, and FWD measurements. The destructive tests included cores for cracking studies and material testing, and trenches for rutting measurements. The laboratory testing planned were the measurement of layer and lift thickness, asphalt binder properties, Hamburg test, and overlay test.

TxDOT was responsible for laboratory material testing, arrangements of road closure, excavation of trenches for rutting, and coring of 4-inch diameter cores for cracking studies. Fugro performed the manual distress surveys, Dipstick® transverse profile measurements, longitudinal profile measurements, FWD measurements, excavation of 6-inch diameter cores for material testing, and assisted the TxDOT crew in completing the 4-inch diameter cores for the crack study. TTI helped with the Hamburg and the Overlay crack resistance tests. With the help of TxDOT, Applied Research Associates collected one trench each from the RAP section and the virgin section for rut depth analysis, as a part of the NCHRP 9-30A project.

CHAPTER 3
ANALYSIS OF RESULTS

3.1 Investigation Data Analysis

3.1.1 Cracking Study

A time series analysis of pre and post overlay manual distress surveys of each section was done to select locations for cores for the study. The analysis identified existing cracks that reflected through the overlay and those newly developed. Most of the cracks in the pavement did not reflect through the overlay, but cracks at new locations were identified. Hence, it was important to identify the layer of crack origin for new cracks and the terminus layer for existing cracks.

For each type of major distress identified in the test section, a replicate core within 0.5 m of the crack was collected to determine the crack origin and compare layer characteristics. A total of 61, 4-inch diameter cores were located in the field for this study. Detailed field core locations are provided in Appendix A of this report. A core log form, tailored to meet the objectives of the investigation, was prepared to collect details of the

project section, core location, core matrix, crack pattern, and pavement layer thickness. Core log documentation of each core and summary is provided in Appendix A.

3.1.2 Cracking Data Analysis

Non-wheel path longitudinal cracking, transverse cracking and fatigue cracking were the major distresses identified. There were a total of 25 cores to study longitudinal cracks, 18 cores for transverse cracks, and 10 cores for fatigue cracking, including the replicate cores. Eight cores (including replicates) were taken at locations were stripping was observed. A summary of data is presented in Appendix A.

Of the eighteen cores collected for the study of transverse cracks, eleven showed a distinctive crack mechanism of origination either on the top or reflecting from the bottom. Out of these eleven cores, eight reflected the existing cracks and three had cracks originating on the surface layer. Reflected transverse cracks were prominent in thin overlay sections of both RAP and virgin mixtures. This was obvious from the results, as seven of the eight bottom-up cracks were in thin overlay sections; four in virgin mixtures and three in RAP mixtures. The remaining one bottom-up crack was in a thick overlay RAP section. All three top-down cracks were observed in virgin mix sections, two in thin overlay and one in thick overlay sections.

For longitudinal cracks, seventeen cores were identified to have a distinctive crack pattern. Twelve of these were noted to be originating at the surface; eight of those were in RAP sections (four in the thin overlay sections and four in the thick overlay sections) and four were in the virgin sections (one in the thin overlay sections and three in the thick overlay sections). Of the five cores identified with bottom-up crack pattern, two were in thick RAP sections and three in virgin mix (two in thin overlay sections and one in thick overlay section).

Six of the cores collected for fatigue cracks were identified to have a distinctive crack pattern. Five of them showed top-down cracking mechanism; four in the RAP section (two in the thin overlay section and one in the thick overlay section) and one in the thick virgin section. One of the cores identified to have reflected the existing crack was in non-milled thick RAP section A503.

Cores were obtained at both wheel path and non-wheel path, where stripping was observed. Only three of the eight cores were completely recovered. For all cores, stripping

was observed on the overlay surface layer except the milled thin overlay RAP section A509, where stripping was observed in binder layers also.

3.1.3 Roughness

Roughness is a measure of ride comfort and a component of pavement performance evaluation. The roughness or rideability of the test section is quantified using the International Roughness Index (IRI). For these test sections, IRI was measured using the LTPP profilometer. It is interesting to note that, even after 17 years of service, all sections but one have a lower IRI than pre-overlay condition (section 48A505). The range of IRI measured is between 1.0-2.0 m/km. A comparative study of the increase in IRI for all sections for 1991, 1992, 1994, 2001, and 2008 was done to see the influence just after treatment, within two years of treatment. It was also done after nine years and after 17 years of treatment. Table 4 summarizes this data and Figure 3 shows the time series plot of IRI over the years.

It is noted that the RAP sections showed excellent performance immediately after the rehabilitation treatment (10% for A502, 25% for A503, 15% for A508, 36% for A509) but exhibited a reduction in performance for the recent year 2008 (-8.0% for A502, 13.2% for A503, -7.0% for A508, 32.2% for A509). Comparing the milled sections (A502, A503) to non-milled sections (A508, A509), thick and thin section respectively, milled sections showed better performance.

Two of the virgin sections showed increased performance (11.8% for A505, 1.0% for A507) immediately after rehabilitation, one non-milled and other milled respectively. Roughness increased over the years for the non-milled section (-14.1% for A505) and decreased for the milled section (12.2% for A507). Two of the virgin sections that showed increased IRI with negative performance just after the treatment (-11.9% for A504, -28.7% for A506) remained more or less the same (-9.0% for A504, -22.5% for A506) over the service life of 17 years.

Comparing IRI values in 2008 with the IRI values after rehabilitation (1992), it is noted that except for section A505, sections with virgin mixture had a lower IRI over the years and outperformed RAP sections. Comparing the roughness of sections before treatment to IRI values in the year 2008, milled sections performed better than non-milled sections.

Table 4. IRI Comparison

State Code	Section ID	Survey Date	Avg IRI	Variation in IRI (%) (All years)	Variation in IRI (%) (1991-1992)	Variation in IRI (%) (1992-2008)	Variation in IRI (%) (1991-2008)
48	A502	19-Mar-91	1.37				
48	A502	20-Jan-92	1.23	-10.2			
48	A502	29-Jun-94	1.27	2.9	10.2	-20.3	-8.0
48	A502	29-Oct-01	1.30	2.5			
48	A502	06-Sep-08	1.48	14.1			
48	A503	19-Mar-91	1.49				
48	A503	21-Jan-92	1.11	-25.5			
48	A503	29-Jun-94	1.18	6.2	25.5	-16.6	13.2
48	A503	29-Oct-01	1.22	3.5			
48	A503	06-Sep-08	1.30	6.1			
48	A504	19-Mar-91	1.38				
48	A504	21-Jan-92	1.54	11.9			
48	A504	29-Jun-94	1.53	-1.0	-11.9	2.5	-9.0
48	A504	29-Oct-01	1.43	-6.6			
48	A504	06-Sep-08	1.50	5.4			
48	A505	20-Mar-91	1.55				
48	A505	22-Jan-92	1.36	-11.8			
48	A505	29-Jun-94	1.46	7.1	11.8	-29.3	-14.1
48	A505	29-Oct-01	1.52	3.9			
48	A505	06-Sep-08	1.76	16.3			
48	A506	19-Mar-91	1.18				
48	A506	21-Jan-92	1.52	28.7			
48	A506	29-Jun-94	1.50	-1.2	-28.7	4.8	-22.5
48	A506	29-Oct-01	1.32	-12.0			
48	A506	06-Sep-08	1.45	9.5			
48	A507	19-Mar-91	1.46				
48	A507	21-Jan-92	1.45	-1.0			
48	A507	29-Jun-94	1.46	0.5	1.0	11.4	12.2
48	A507	29-Oct-01	1.28	-12.1			
48	A507	06-Sep-08	1.28	0.3			
48	A508	19-Mar-91	1.26				
48	A508	20-Jan-92	1.06	-15.4			
48	A508	29-Jun-94	1.15	8.0	15.4	-26.6	-7.1
48	A508	29-Oct-01	1.19	3.8			
48	A508	06-Sep-08	1.35	12.9			
48	A509	19-Mar-91	1.95				
48	A509	20-Jan-92	1.24	-36.1			
48	A509	29-Jun-94	1.25	0.6	36.1	-6.1	32.2
48	A509	29-Oct-01	1.21	-3.5			
48	A509	06-Sep-08	1.32	9.3			

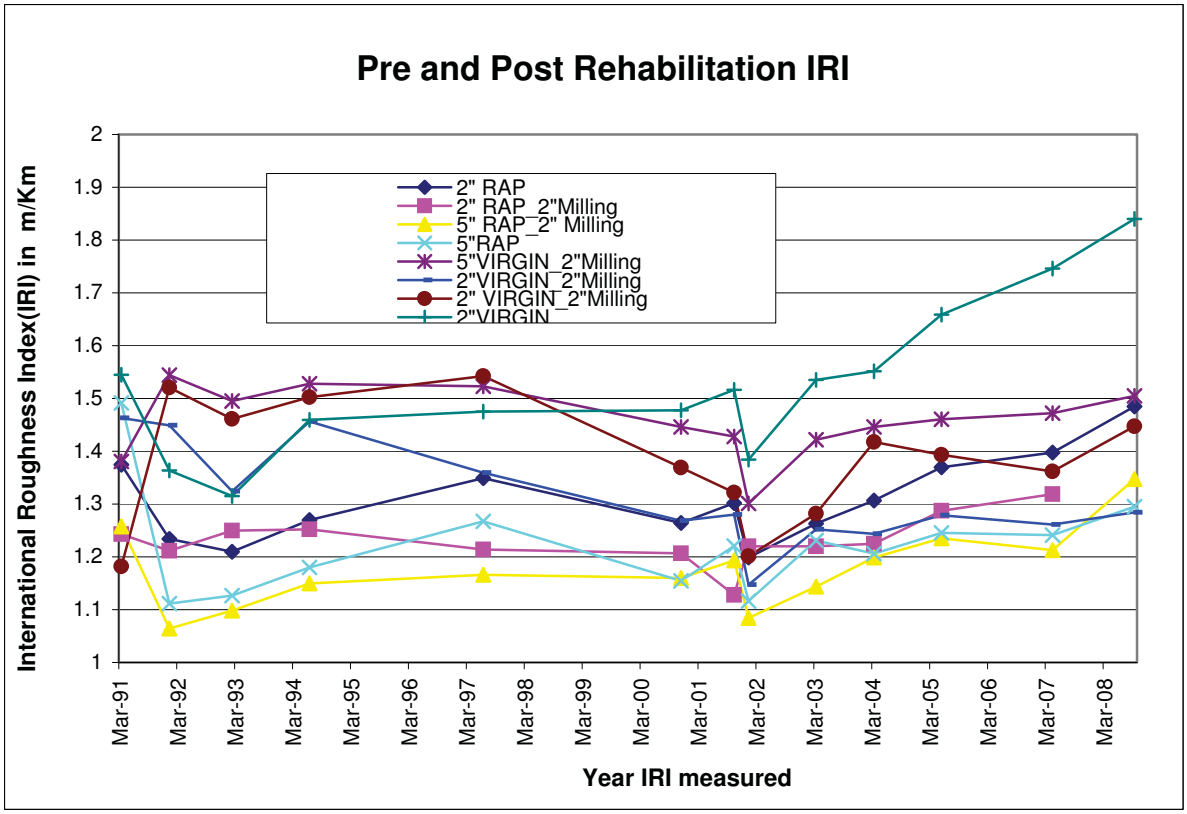


Figure 3: Plot of IRI the Years

3.1.4 Longitudinal Cracking

Longitudinal cracking (all severity levels) in the wheel path and non-wheel path of each of the eight test sections were plotted against time to evaluate the performance. Only the automated PASCO distress survey was available for pre-overlay distress assessment. Since most of the sections had block cracking, these automated surveys masked other distresses in those areas, and a fair comparison of the longitudinal cracking before and after treatment was not obtained for sections A502 and A509. When comparing the total length of longitudinal non-wheel path (LNWP) cracks available before treatment with the manual distress survey data as shown in Figure 4, it is surprising that even after 17 years of service, none of the sections exhibited the same amount of distress before treatment. The trend of a lower wheel path cracking when compared to the non-wheel path cracking was noted in all sections. Table 5 and 6 show the percentage variation of longitudinal distresses in the wheel path and non-wheel path in 1993, after 7 years (1998), after 12 years (2003) and after 17 years (2008) of surface treatment.

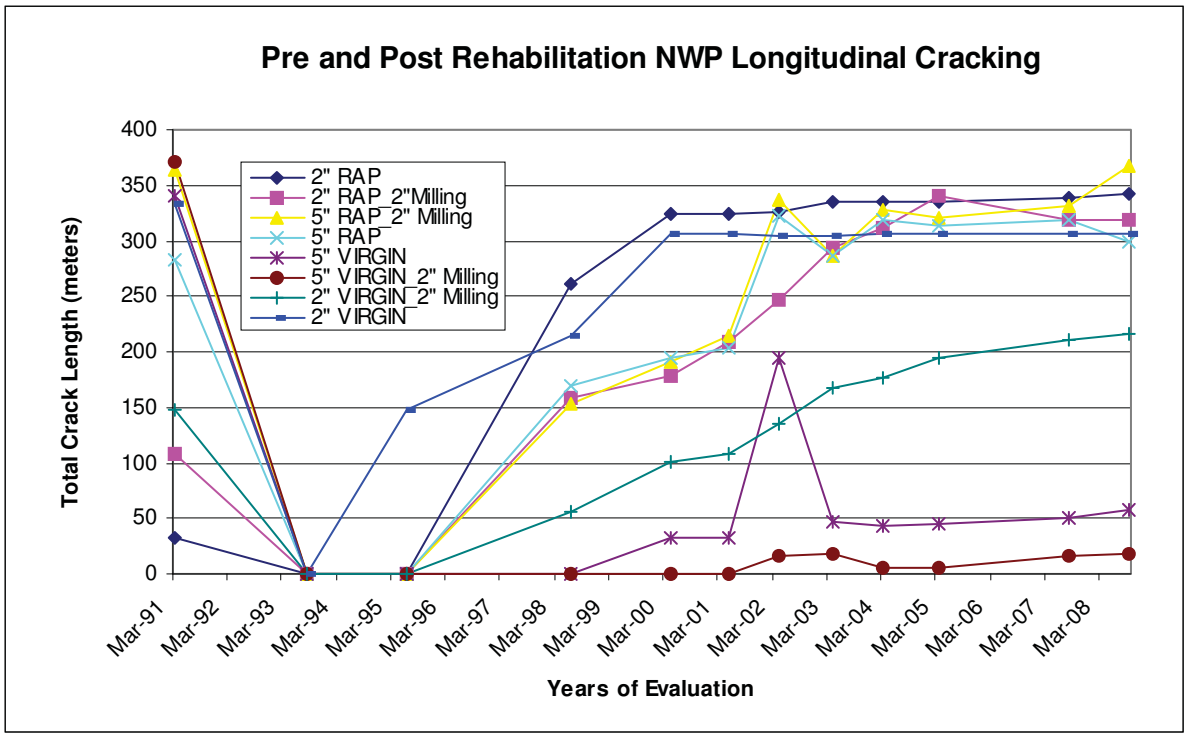


Figure 4: Plot of Longitudinal Non-Wheel Path Cracks Over the Years

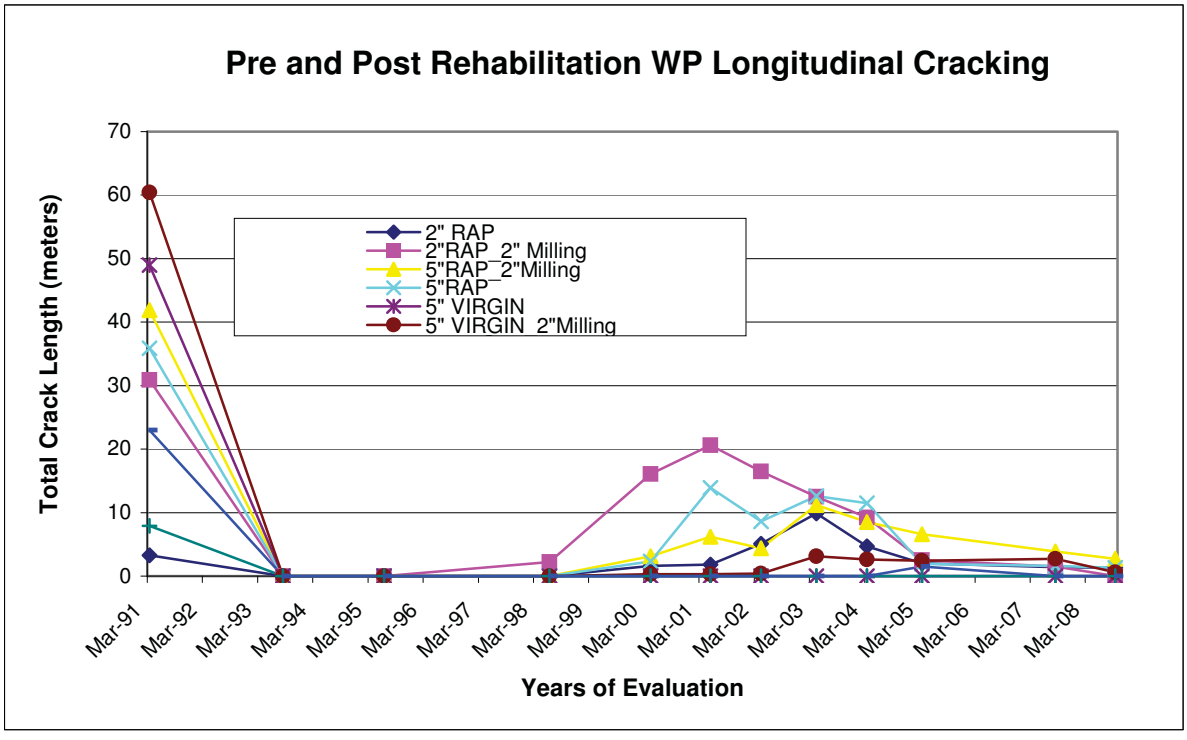


Figure 5: Plot of Longitudinal Wheel Path Cracks Over the Years

All virgin sections except section A507 (99% reduction), showed 100% reduction in wheel path longitudinal cracks. RAP sections also showed a reduction in wheel path longitudinal cracks as noted here for thin non-milled/milled, (60.6% for A502, 100% for A509) thick non-milled /milled sections (93.6% for A508 and 96.4% for A503) respectively. The least reduction was observed in non-milled thin overlay RAP section A502.

All RAP sections exhibited a high amount of longitudinal non-wheel path cracking around 7 to 10 years of service after rehabilitation. During the initial 7 years, the rate of increase in longitudinal non-wheel path cracks was high for RAP sections (37.4% for A502, 22.6 for A509, 22.0% for A508, 24.1% for A503) compared to virgin sections (0.0% for A504, 0.0% for A507, 8.0% for A506, 30.7% for A505). Comparing the rate of increase 7 years after treatment, (8.1% for A502, 16.0 for A509, 21.4% for A508, 13.1% for A503) and virgin sections (5.7% for A504, 1.8% for A507, 16.1% for A506, 9.1% for A505), show that the cracking rate slows down for the RAP sections, but starts increasing for the virgin sections.

As compared above, for virgin sections, less longitudinal non-wheel path cracking was reported compared to that reported before the overlay. Virgin mixes reflected less cracking than recycled mixes, except for section 48A505, which is the thin non-milled section that immediately reflected the cracking before any other section. The other milled thin overlay virgin mixture showed 8.0% crack rate within the initial 7 years and increased to 16.0% thereafter. Virgin mixture thick overlay sections, both milled and non milled, showed 0.0% increase in cracking for the first 7 years, but cracking there after at a rate of 5.7% for non-milled and 1.8% for milled sections. Within the thin and thick virgin sections, the ones that reduced the existing crack from reflecting on the surface without surprise were the thick overlay sections, both milled and non-milled.

Comparing the performance of milled and non-milled thick virgin mix overlay sections, it is noted that the milled section reported less longitudinal non-wheel path cracking over the service period. In non-milled sections, though the cracks reflected for some time, the thick virgin mixture helped heal these cracks. For thin virgin mix overlay section also, the milled section performed better when compared to the non-milled section.

Table 5. Longitudinal Wheel Path Crack Comparison

State Code	Section_ID	Survey Date	Total Length of LWP Crack	Variation in LWP (%) (1991- 2008)
48	A502	08-Mar-91	3.3	60.6
48	A502	10-Aug-93	0	
48	A502	03-Jun-98	0	
48	A502	23-Apr-03	9.9	
48	A502	10-Sep-08	1.3	
48	A509	08-Mar-91	30.9	100.0
48	A509	10-Aug-93	0	
48	A509	03-Jun-98	2.2	
48	A509	23-Apr-03	12.5	
48	A509	10-Sep-08	0	
48	A508	08-Mar-91	41.9	93.6
48	A508	10-Aug-93	0	
48	A508	03-Jun-98	0	
48	A508	23-Apr-03	11.2	
48	A508	10-Sep-08	2.7	
48	A503	08-Mar-91	35.9	96.4
48	A503	10-Aug-93	0	
48	A503	03-Jun-98	0	
48	A503	23-Apr-03	12.6	
48	A503	11-Sep-08	1.3	
48	A504	08-Mar-91	49	100.0
48	A504	10-Aug-93	0	
48	A504	03-Jun-98	0	
48	A504	23-Apr-03	0	
48	A504	11-Sep-08	0	
48	A507	08-Mar-91	60.4	99.0
48	A507	10-Aug-93	0	
48	A507	03-Jun-98	0	
48	A507	23-Apr-03	3.1	
48	A507	11-Sep-08	0.6	
48	A506	08-Mar-91	7.9	100.0
48	A506	10-Aug-93	0	
48	A506	04-Jun-98	0	
48	A506	23-Apr-03	0	
48	A506	11-Sep-08	0	
48	A505	08-Mar-91	23	100.0
48	A505	10-Aug-93	0	
48	A505	04-Jun-98	0	
48	A505	24-Apr-03	0	
48	A505	11-Sep-08	0	

Table 6. Longitudinal Non Wheel Path (LNWP) Crack Comparison

State Code	Section_ID	Survey Date	Total_ NWP	Variation of LNWP (%) (1991-2008)	Rate of LNWP Increase (%) (1993-1998)	Rate of LNWP Increase (%) (1998-2008)
48	A502	08-Mar-91	32.7	-950.0	37.4	8.1
48	A502	10-Aug-93	0			
48	A502	03-Jun-98	261.8			
48	A502	23-Apr-03	334.7			
48	A502	10-Sep-08	342.6			
48	A509	08-Mar-91	107.4	-200.0	22.6	16.0
48	A509	10-Aug-93	0			
48	A509	03-Jun-98	158.5			
48	A509	23-Apr-03	294.3			
48	A509	10-Sep-08	318.2			
48	A508	08-Mar-91	363.1	-1.2	22.0	21.4
48	A508	10-Aug-93	0			
48	A508	03-Jun-98	153.8			
48	A508	23-Apr-03	285.9			
48	A508	10-Sep-08	367.5			
48	A503	08-Mar-91	283.4	-5.6	24.1	13.1
48	A503	10-Aug-93	0			
48	A503	03-Jun-98	168.6			
48	A503	23-Apr-03	286.3			
48	A503	11-Sep-08	299.4			
48	A504	08-Mar-91	340.3	83.2	0.0	5.7
48	A504	10-Aug-93	0			
48	A504	03-Jun-98	0			
48	A504	23-Apr-03	47.5			
48	A504	11-Sep-08	57.3			
48	A507	08-Mar-91	370.4	95.2	0.0	1.8
48	A507	10-Aug-93	0			
48	A507	03-Jun-98	0			
48	A507	23-Apr-03	18.8			
48	A507	11-Sep-08	17.9			
48	A506	08-Mar-91	147.3	-47.0	8.0	16.1
48	A506	10-Aug-93	0			
48	A506	04-Jun-98	56			
48	A506	23-Apr-03	167.9			
48	A506	11-Sep-08	216.5			
48	A505	08-Mar-91	333.7	8.2	30.7	9.1
48	A505	10-Aug-93	0			
48	A505	04-Jun-98	215			
48	A505	24-Apr-03	305.1			
48	A505	11-Sep-08	306.4			

3.1.5 Transverse Cracking

A time series plot of the total length of transverse cracks (all severities) for each test section was prepared to compare the distress before and after rehabilitation treatment, as shown in Figure 6. As noted before, only the automated PASCO distress survey was available before treatment for distress analysis, and in most sections these were reported as block cracking that masked other distresses, including transverse cracks in sections A509 and A502.

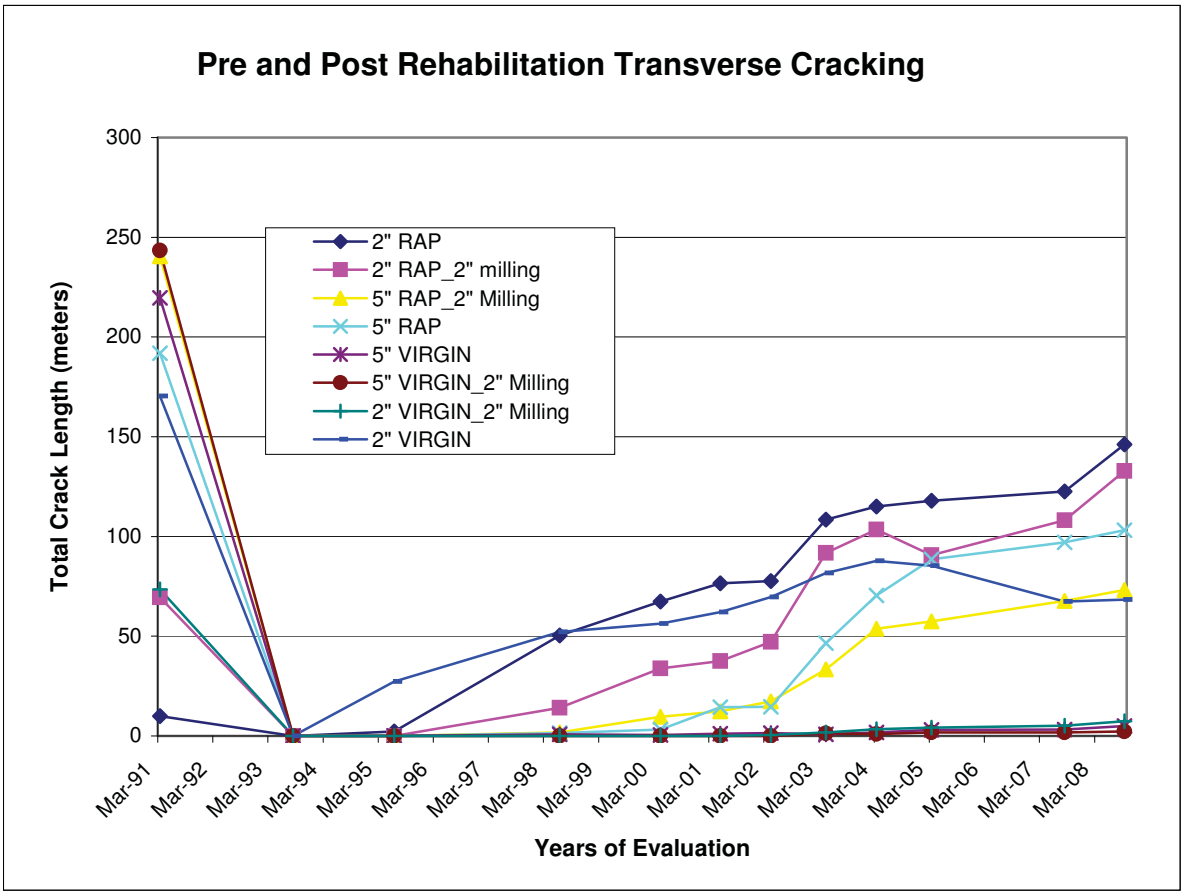


Figure 6: Plot of Transverse Cracks Over the Years

Comparing the total number of cracks before rehabilitation to the cracks in 2008, it is noted that resistance to transverse cracks in thick non-milled/milled and thin non-milled/milled of virgin sections was high (97.7% for A504, 99.1% for A507, 89.9% for A506, 59.9% for A505) compared to RAP sections (46.2% for A503, 69.6% for A508, 11.4 for A509, 2.5% for A 502), as may be seen in Table 7.

Table 7. Transverse Crack (T_Crack) Comparison

State Code	SHRP_ID	Survey Date	Total Length T_Crack	Variation in T_Cracks (%) (1991-2008)	Rate of T_Crack increase (1992-2008)	Rate of T_Crack increase (1998-2008)
48	A502	08-Mar-91	9.9	2.5	7.2	9.6
48	A502	10-Aug-93	0			
48	A502	03-Jun-98	50.3			
48	A502	23-Apr-03	108.4			
48	A502	10-Sep-08	146.2			
48	A509	08-Mar-91	69.4	11.4	2.0	11.9
48	A509	10-Aug-93	0			
48	A509	03-Jun-98	14.1			
48	A509	23-Apr-03	91.8			
48	A509	10-Sep-08	132.9			
48	A508	08-Mar-91	240.5	69.6	0.2	7.1
48	A508	10-Aug-93	0			
48	A508	03-Jun-98	1.7			
48	A508	23-Apr-03	33.4			
48	A508	10-Sep-08	73.1			
48	A503	08-Mar-91	191.9	46.2	0.2	10.2
48	A503	10-Aug-93	0			
48	A503	03-Jun-98	1.5			
48	A503	23-Apr-03	46.6			
48	A503	11-Sep-08	103.2			
48	A504	08-Mar-91	219.6	97.7	0.1	0.4
48	A504	10-Aug-93	0			
48	A504	03-Jun-98	0.8			
48	A504	23-Apr-03	0.8			
48	A504	11-Sep-08	5			
48	A507	08-Mar-91	243.4	99.1	0.0	0.2
48	A507	10-Aug-93	0			
48	A507	03-Jun-98	0			
48	A507	23-Apr-03	1.3			
48	A507	11-Sep-08	2.2			
48	A506	08-Mar-91	73.4	89.9	0.0	0.7
48	A506	10-Aug-93	0			
48	A506	04-Jun-98	0			
48	A506	23-Apr-03	1.8			
48	A506	11-Sep-08	7.4			
48	A505	08-Mar-91	170.3	59.9	7.5	1.6
48	A505	10-Aug-93	0			
48	A505	04-Jun-98	52.2			
48	A505	24-Apr-03	81.7			
48	A505	11-Sep-08	68.3			

Within seven years of the surface treatment, the rate of increase in transverse cracks is high in thin overlays non-milled/milled when compared to RAP sections (7.2% for A502, 2.0 % for A509). Both milled and non-milled thick RAP sections show less than 0.2% increase. This rate is found to be increasing after seven years at a range of 10% for all the RAP sections. For virgin sections, the rate of increase in transverse crack after 7 years of treatment was less than 0.4% for thick sections and less than 1.6% for thin sections.

Sections with a thick overlay of virgin mixture showed high resistance to reflection of existing transverse cracking. In general, thicker overlays had less cracking than thinner overlays, and milled sections had less cracks than those with minimal surface preparation.

3.1.6 Deflection (FWD) Measurements

FWD measurements are used as a measure of structural capacity evaluation of each layer of the pavement. Seven sensors located at known distances, measure the deflection of the pavement in response to weights dropped from fixed heights. Sensor 7 deflections correspond to the subgrade condition and sensor 1 deflections correspond to the overall pavement condition.

Pre and post FWD measurements for sensors 1 and 7 are plotted for each year as shown in Figures 7 and 8 to analyze the structural capacity of each underlying layer. These are deflections without temperature correction average for the project location and normalized for a drop load of 9 kips. Sensor 1 plots show that there is considerable increase in structural capacity for all sections following rehabilitation in 1991. For all sections, the sensor 1 deflections reported were less than 90 microns compared to the deflections in the range of 120 to 250 microns before treatment. Though not significant, the deflection noted in subgrade layers also decreased for all the sections with rehabilitation. The surveys in recent years show that both sensor 1 and sensor 7 deflections started increasing after 7-10 years of service life. According to recent FWD measurements, increases in deflection for the surface and subgrade layers is observed in the non-milled thin overlay RAP section A502 (108%) and the lowest increase in deflection is observed in non-milled 5 inch thick RAP section A503 (44%). Variations in deflections are observed in 2002 and 2005, as the temperature at the time the FWD measurement was taken varied considerably within the two days of successive data collection.

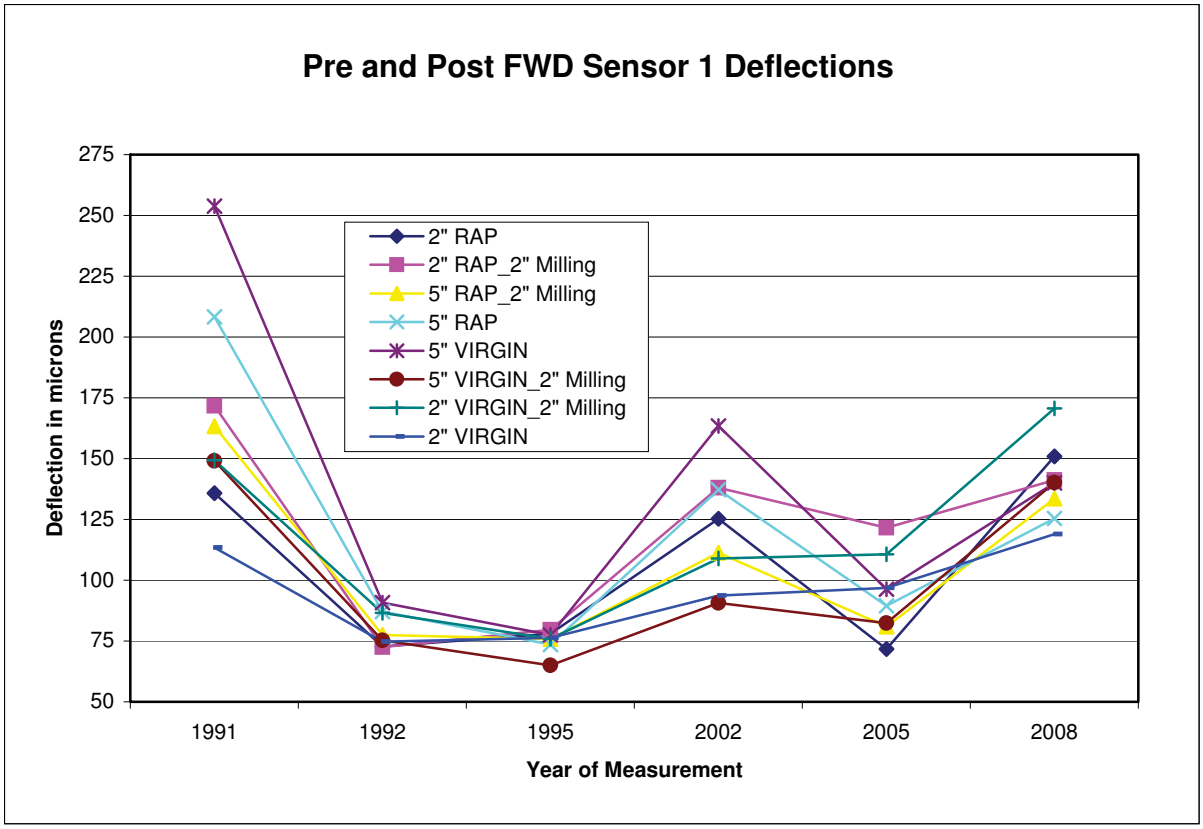


Figure 7: Plot of Sensor 1 FWD Measurement Over the Years

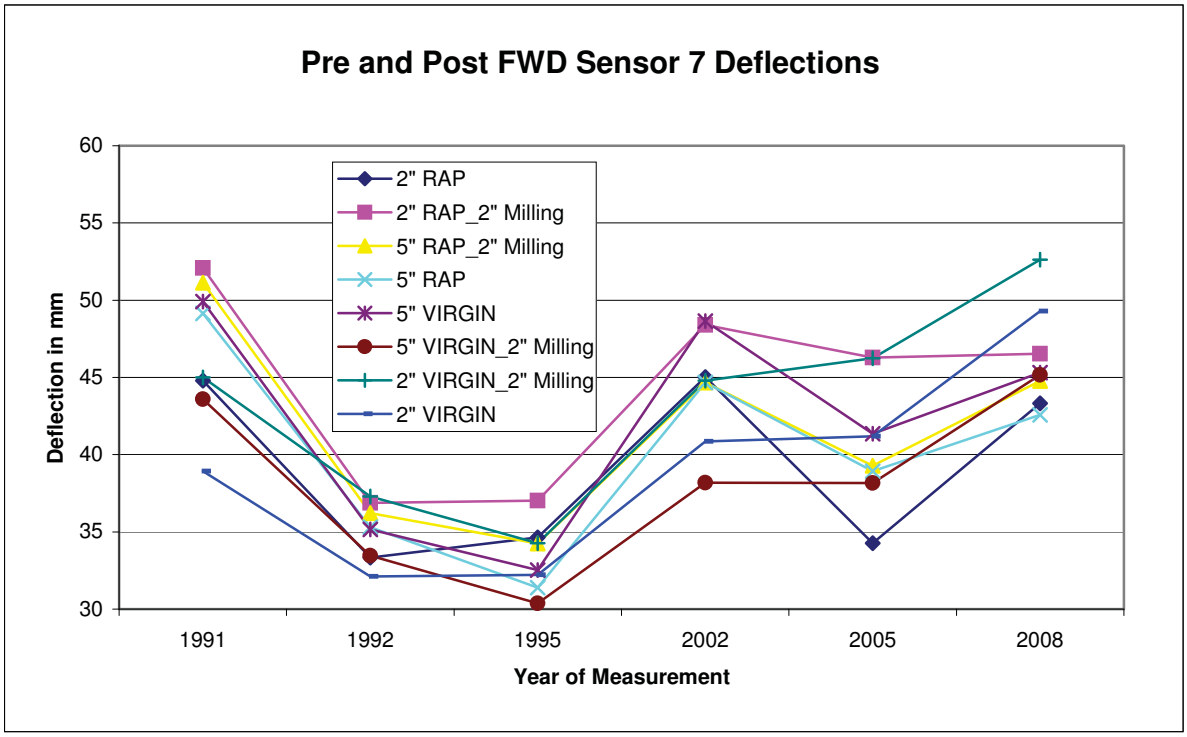


Figure 8: Plot of Sensor 7 FWD Measurement Over the Years

As noted in other distresses, thicker sections of both RAP and virgin mixtures showed increased strength. Milled sections with 7-inch overlay of both RAP and virgin mixtures showed comparably better performance (72% and 86% increase) and thin sections showed 95% and 97% increase respectively. Non-milled thin sections of virgin mixtures showed less deflection (59% increase) compared to 108% increase in RAP section.

In general, thicker sections showed less deflection in milled and non-milled sections of both RAP and virgin mixtures. Milled thin sections performed better than non-milled sections in RAP, but milling did not help in reducing deflection in thin sections of virgin mix.

3.1.7 Rutting

For trenching locations at the SPS-5 project, a rut data analysis was done as a part of NCHRP project 9-30A. A complete report is not currently available, but the field report shows that most of the rutting has occurred within the HMA overlay-wearing surface. A summary of the analysis is noted below and the detailed report is provided in Appendix C for reference.

The rutting in section A508 is confined to the surface RAP layer, with a maximum of 0.25 in. Immeasurable rutting was found within the lower layers of the RAP overlay. For section A507, rutting has occurred within the surface layer of the virgin HMA with a maximum of about 0.2 in. centered in the wheel path, and continues into the bottom of the binder layer (leveling lift) to a magnitude of about 0.2 in. The lower lift of the virgin mix for binder layer or leveling course was reported to have tensile strength ratios (TSR) lower than the minimum required value of 0.70. Some of this rutting in the leveling course could be associated with moisture damage within that layer. The TSR values reported for the RAP mixtures all exceeded the minimum value of 0.70 and no measurable rut depths were found within that layer from the trench in section A508.

Three lifts were placed for the overlay; the wearing surface, the binder layer and a leveling course. Based on an analysis of the measured rut depths, all measurable rutting has occurred in the HMA overlay. Most of the rutting has occurred within the wearing surface of both sections. It is expected that immeasurable rutting has occurred in the existing HMA and other lower layers.

3.1.8 Laboratory Material Testing

Three, 6-inch diameter cores from virgin AC section A504 and three cores from recycled section A503 were tested by TxDOT for layer thickness, density, binder content, penetration, DSR, and Hamburg Wheel Track Test. Comparing the job mix design values of the surface layers and the lab results of the binder layers, it is noted that the as-constructed data strictly follows the mix design values. Comparison of recent test results from TxDOT to previous data obtained from LTPP database is presented in Table 8. A detailed laboratory test result analysis is provided in the TxDOT report is included in Appendix B.

Table 8. Comparison of Asphalt Mix Test Results

Layer G (Overlay Surface _RAP) Asphalt Grade (AC-5)					
Protocol ID*	**Properties**	**1991 (Job Mix)**	**1992 (LTPP)**	**2007 (LTPP)**	**2008 (TxDOT)**
AC01	Layer Thickness (in)	2.00	2.14	1.95	2.047
AC02	Bulk Spec. Gravity	2.441	2.443	2.526	2.501
	Water Absorption (%)				0.255
AC03	Max.Spec.Gravity	2.542	-	2.549	2.530
	Density (%)	96			98.855
AC04	Asphalt Content (%)	4.5	-	4.2	4.633
AE02	Pen at 77F (p.u.)		-	-	18.000
AE03	Spec.Gravity at 66C	0.985	-	1.033	1.034
	Spec.Gravity at 77C				1.028
	DSR @ 64				6.555
	DSR @ 70				2.795
	DSR @ 76				1.313
AE05	Abs.Viscosity (P)		-	30919.67	13527.84
Layer F (Overlay Binder _RAP) Asphalt Grade (AC-5)					
Protocol ID*	**Properties**	**1991 (Job Mix)**	**1992**	**2007**	**2008 (TxDOT)**
AC01	Layer Thickness (in)		3.17	3.13	2.963
AC02	Bulk Spec. Gravity	2.424	2.443	-	2.391
	Water Absorption (%)				0.607
AC03	Max.Spec.Gravity	2.514	2.534	2.533	2.512
	Density (%)	96.4			95.20
AC04	Asphalt Content (%)	3.8	4.1	4.133	3.833
AE02	Pen at 77F (p.u.)		39.667	-	27.333
AE03	Spec.Gravity at 66C		1.031	1.033	1.029
	Spec.Gravity at 77C	0.985			1.023
	DSR @ 64				4.773
	DSR @ 70				2.093
	DSR @ 76				0.965
AE05	Abs.Viscosity (P)		5625.8	30250.67	9533.29

Table 8. Comparison of Asphalt Mix Test Results (Cont…)

Layer I (Overlay Surface_VIRGIN) Asphalt Grade (AC 10 with 3% Latex)					
Protocol ID*	**Properties**		**1992 (LTPP)**	**2007 (LTPP)**	**2008 (TxDOT)**
AC01	Layer Thickness (in)		2.106	1.995	2.063
AC02	Bulk Spec. Gravity		-	-	2.535
	Water Absorption (%)				0.125
AC03	Max.Spec.Gravity		2.519	-	2.560
	Density (%)				99.03
AC04	Asphalt Content (%)		5.033	4.867	5.300
AE02	Pen at 77F (p.u.)		31.000	-	64.00
AE03	Spec.Gravity at 66C		1.038	-	1.050
	Spec.Gravity at 77C				1.044
	DSR @ 64				1.803
	DSR @ 70				0.883
	DSR @ 76				0.452
AE05	Abs.Viscosity (P)		9081.33	-	2296.02
Layer H (Overlay Binder_VIRGIN) Asphalt Grade (AC 10 with 3% Latex)					
Protocol ID*	**Properties**		**1992 (LTPP)**	**2007 (LTPP)**	**2008 (TxDOT)**
AC01	Layer Thickness (in)		2.883	2.780	2.446
AC02	Bulk Spec. Gravity		2.473	2.343	2.443
	Water Absorption (%)				0.164
AC03	Max.Spec.Gravity		2.557	-	2.514
	Density (%)				97.17
AC04	Asphalt Content (%)		4.467	4.567	4.533
AE02	Pen at 77F (p.u.)		-	-	48.67
AE03	Spec.Gravity at 66C		1.034	-	1.032
	Spec.Gravity at 77C				1.026
	DSR @ 64				1.597
	DSR @ 70				0.795
	DSR @ 76				0.433
AE05	Abs.Viscosity (P)		4199	-	2946.53
* Protocol ID mentioned are the LTPP Material Testing Protocols					

Table 8. Comparison of Asphalt Mix Test Results (Cont…)

Layer E (Existing Pavement Surface)					
Protocol ID*	**Properties**		**1992 (LTPP)**	**2007 (LTPP)**	**2008 (TxDOT)**
AC01	Layer Thickness (in)		1.350	1.221	1.433
AC02	Bulk Spec. Gravity		2.392	2.385	2.408
	Water Absorption (%)				0.850
AC03	Max.Spec.Gravity		2.466	-	2.478
	Density (%)				97.15
AC04	Asphalt Content (%)		4.800	4.650	4.750
AE02	Pen at 77F (p.u.)		11.333	-	10.500
AE03	Spec.Gravity at 66C		1.060	-	1.045
	Spec.Gravity at 77C				1.039
	DSR @ 64				17.75
	DSR @ 70				8.749
	DSR @ 76				3.805
AE05	Abs.Viscosity (P)		354296.67	-	45780.26
Layer D (Existing Pavement Binder)					
Protocol ID*	**Properties**		**1992 (LTPP)**	**2007 (LTPP)**	**2008 (TxDOT)**
AC01	Layer Thickness (in)		7.850	7.597	7.921
AC02	Bulk Spec. Gravity		2.358	2.350	2.363
	Water Absorption (%)				0.949
AC03	Max.Spec.Gravity		2.412	-	2.416
	Density (%)				97.81
AC04	Asphalt Content (%)		4.700	4.133	5.033
AE02	Pen at 77F (p.u.)		24.333	-	23.50
AE03	Spec.Gravity at 66C		1.052	-	1.045
	Spec.Gravity at 77C				1.039
	DSR @ 64				3.293
	DSR @ 70				1.455
	DSR @ 76				0.696
AE05	Abs.Viscosity (P)		138492.33	-	6002.10
* Protocol ID mentioned are the LTPP Material Testing Protocols					

DISCUSSION

Pavement performance is an interwoven fabric of different parameters of varying influence. It was found that after more than 17 years of service, the RAP sections have been performing satisfactory for the Texas SPS-5 sections. Different factors were identified to have helped improve the performance of these sections.

Primarily, it is believed that the mixture design helped reduce aging of the asphalt mixture. The high asphalt content and high densities are believed to have contributed to reduced oxidation and enhanced the crack resistance. The results from the SPS-5 test sections suggest that a flexible mix will be able to bridge over the cracked surface. For both RAP and virgin sections, the study indicates that a thicker overlay does contribute to reflective crack resistance. The milled sections showed slightly lower amount of cracks, but the mechanistic and empirical analysis shows that the effect of milling is insignificant in resisting reflection cracking unless existing cracks are completely removed. A distinct crack mechanism is not observed for these sections in the cracking study. It showed that most of the transverse cracks were bottom-up. Longitudinal non-wheel path cracks were also noted to originate at pavement surface in thicker overlay sections, besides that reflected from the existing crack below. Within the first 8 years of service, there is no significant difference between RAP and virgin AC sections. Compared to virgin mixture, the RAP sections showed increased rate of distress after 8 years of service. This could be explained by the recent asphalt binder penetration results indicating that RAP sections are undergoing aging to some extent. The overlay tester results indicate that the AC overlay with virgin asphalt mix still possesses excellent resistance to reflective cracking.

Using quality materials, especially water resistant aggregates, has helped improve the performance. In general, aggregates with low water absorption perform well since less asphalt is absorbed thus producing a thicker film of asphalt around the aggregates. This generally produces a mixture less prone to excessive aging and cracking. Using of high quality aggregates might be extremely expensive in some areas, where it is not locally available. A cost analysis considering the long-term performance of the pavement may be necessary to select the aggregate type for the pavement mixture design.

Good quality aggregate and sound foundation might have also contributed to the low rutting reported in these sections. Even after 17 years of service, maximum rutting reported was less than half inch. RAP overlay mixture showed less rutting compared to virgin mixture. The preliminary observations of the rut depth analysis noted that all the measurable rutting has occurred in the overlay layer. Rutting was found within the surface layer of the overlay for both RAP and virgin mixture. But virgin mixture reported lower tensile strength ratio in the lower layer of overlay and found to have rutted in this layer. It is believed that this could be associated with the moisture damage within this layer. The tensile strength ratio reported for RAP mixture exceeded the minimum requirement and no measurable rut depths were observed within the lower overlay layer.

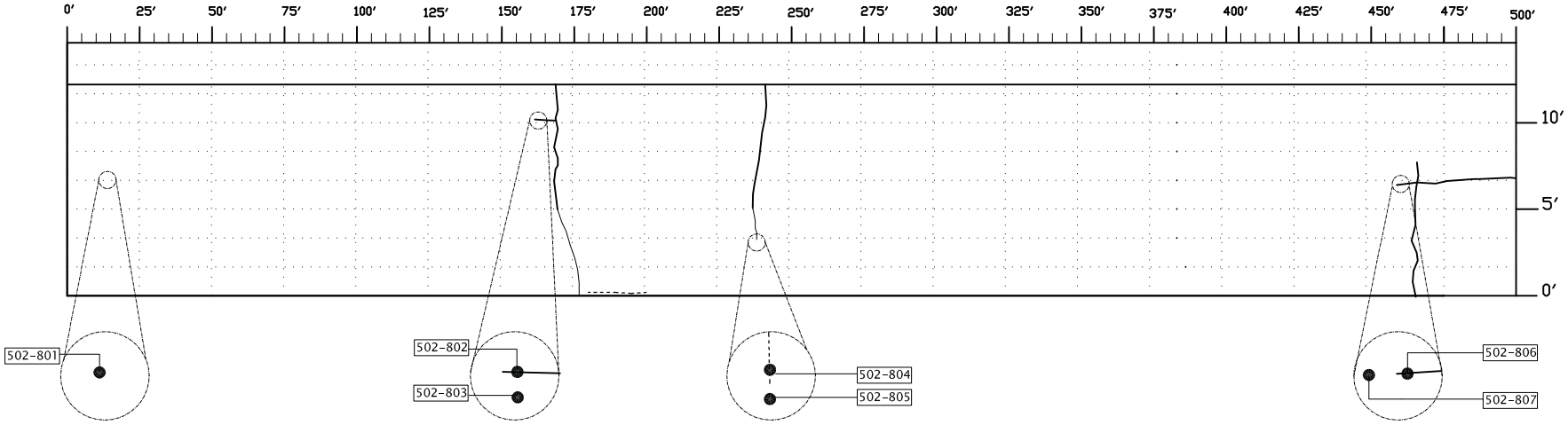
The in-situ mixture properties matched the design mixture properties for the Texas SPS-5 project, showing the quality of construction practice followed. The asphalt content determined for the cores collected were within 0.3% of the original design target. A high in-place density of about 96% to 99% is reported in all tests. The results clearly support the influence of quality construction practice in pavement performance.

Due to the benefits in costs reduction and environmental protection, there is a great tendency to use RAP. However, the most frequently observed distress associated with RAP is reflective cracking. Thus, the performance of RAP and factors influencing it are important factors for pavement engineers to consider when making decisions on rehabilitation and maintenance activities. The overall performance of RAP mixture overlays in the Texas SPS-5 sections was comparable to virgin mixture overlay. As mentioned above several factors influenced the excellent performance of these RAP sections. In the present scenario of minimizing expenses, the findings of this study would appear to support the continued use of RAP, and excellent performance when properly designed and constructed.

APPENDIX A

CRACK STUDY DATA

SECTION: 48_A502



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
502-801	LONGITUDINAL CRACKING NOT REFLECTED	4" DIA	15+00, 06+00
502-802	FATIGUE CRACKING	4" DIA	170+20, 03+00
502-803	FATIGUE CRACKING - REPLICATE CORE	4" DIA	170+20, 02+60
502-804	TRANSVERSE CRACKING	4" DIA	248+00, 04+00
502-805	TRANSVERSE CRACKING - REPLICATE CORE	4" DIA	248+00, 03+60
502-806	LONGITUDINAL CRACKING	4" DIA	465+00, 08+00
502-807	LONGITUDINAL CRACKING -REPLICATE CORE	4" DIA	464+60, 08+00

LAYER CODE	LAYER DESCRIPTION
6- G	2.2" AC OVERLAY - RAP
5 - E	1.3" ORIGINIAL AC SURFACE
4- D	7.9" AC BINDER
3- C	14" LIME STABILIZED CSB
2- B	8" LTS
1- A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

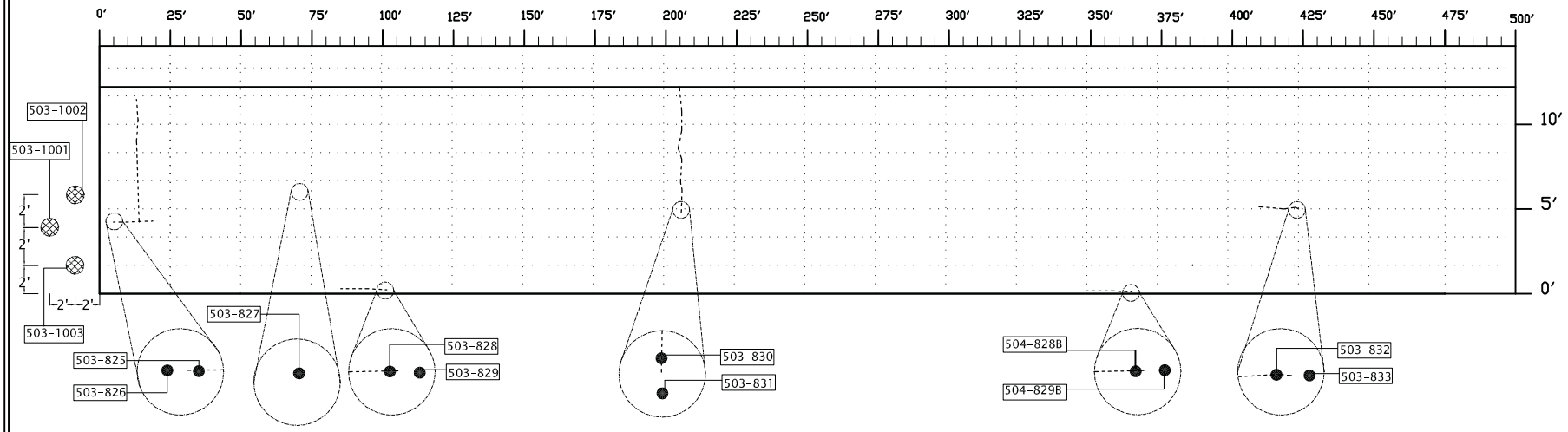
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A502

SECTION: 48_A503



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
503-825	FATIGUE CRACKING	4" DIA	06+00, 4+00
503-826	FATIGUE CRACKING - REPLICATE CORE	4" DIA	06+40, 04+00
503-827	EXISTING CRACK NOT REFLECTED	4" DIA	74+00, 06+00
503-828/ 828B	REFLECTED LONGITUDINAL CRACKING	4" DIA	100+00, 0+00 / 365+00, 0+00
503-829/ 829B	LONGITUDINAL CRACKING - REPLICATE CORE	4" DIA	100+40, 0+00 / 365+40, 0+00
503-830	REFLECTED TRANSVERSE CRACKING	4" DIA	210+00, 05+00
503-831	TRANSVERSE CRACKING - REPLICATE CORE	4" DIA	210+00, 04+60
503-832	REFLECTED LONGITUDINAL CRACKING	4" DIA	425+00, 05+00
503-833	LONGITUDINAL CRACK - REPLICATE CORE	4" DIA	425+40, 05+00
503-1001 TO 1003	CORES FOR EXTRACTING BINDER FOR BINDER TESTS	12" DIA	3 BULK CORES BEFORE SECTION 48_A503

LAYER CODE	LAYER DESCRIPTION
7 - G	2.1" AC OVERLAY - RAP
6 - F	3.2" AC OVERLAY BINDER- RAP
5 - E	1.4" ORIGINIAL AC SURFACE
4 - D	8" AC BINDER
3 - C	12" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

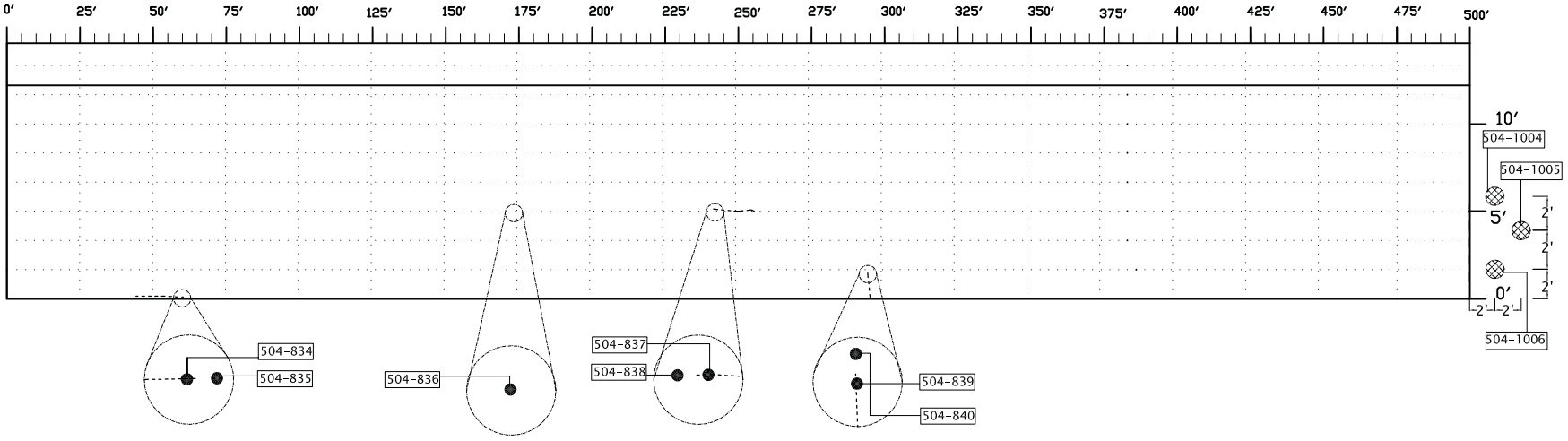
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A503

SECTION: 48_A504



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
504-834	LONGITUDINAL CRACKING	4" DIA	65+00, 0+00
504-835	LONGITUDINAL CRACKING - REPLICATE CORE	4" DIA	65+00, 0+00
504-836	CRACKING NOT REFLECTED	4" DIA	175+00, 05+00
504-837	RAVELING	4" DIA	230+00, 05+00
504-838	RAVELING - REPLICATE CORE	4" DIA	229+60, 05+00
504-839	REFLECTED TRANSVERSE CRACKING	4" DIA	299+00, 02+00
504-840	CRACKING NOT REFLECTED - REPLICATE CORE	4" DIA	299+00, 02+40
504-1004 TO 1006	CORES FOR EXTRACTING BINDER FOR BINDER TESTS	12" DIA	3 BULK CORES AFTER SECTION 48_A504

LAYER CODE	LAYER DESCRIPTION
7 - I	2.2" AC OVERLAY - VIRGIN
6 - H	3.1" AC OVERLAY BINDER- VIRGIN
5 - E	1.2" ORIGINIAL AC SURFACE
4 - D	7.5" AC BINDER
3 - C	10" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

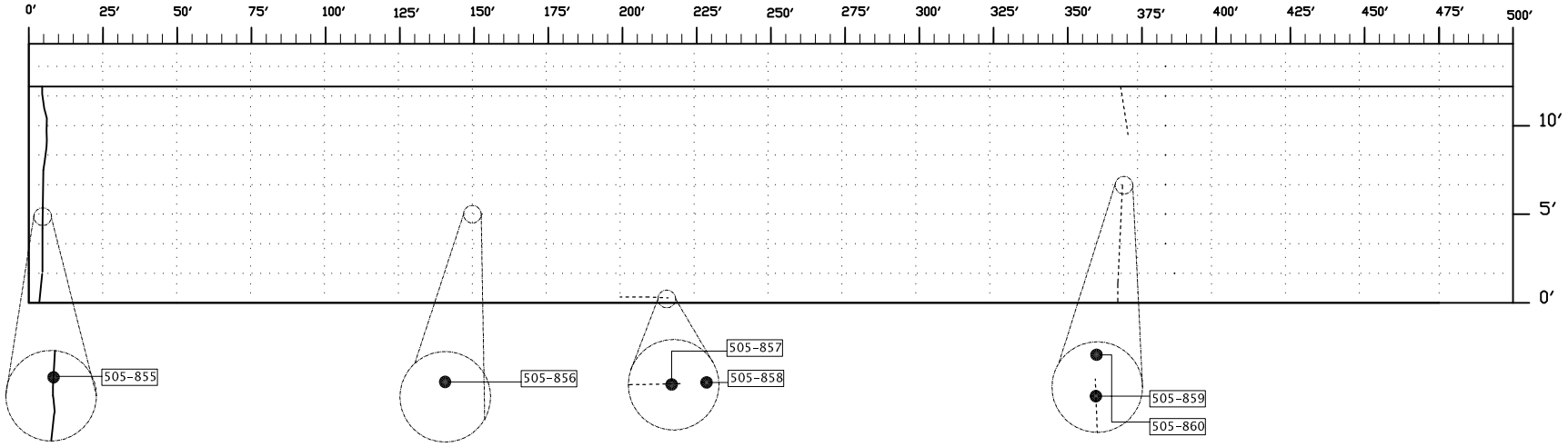
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A504

SECTION: 48_A505



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
505-855	TRANSVERSE CRACKING	4" DIA	05+60, 05+00
505-855	TRANSVERSE CRACKING - REPLICATE CORE	4" DIA	06+00, 05+00
505-856	EXISTING CRACK NOT REFLECTED	4" DIA	150+00, 05+00
505-857	LONGITUDINAL CRACKING	4" DIA	220+00, 05+00
505-858	LONGITUDINAL CRACKING - REPLICATE CORE	4" DIA	220+40, 0+00
505-859	REFLECTED TRANSVERSE CRACKING	4" DIA	360+00, 06+00
505-860	TRANSVERSE CRACKING - REPLICATE CORE	4" DIA	360+00, 06+40

LAYER CODE	LAYER DESCRIPTION
6 - I	2.0" AC OVERLAY - VIRGIN
5 - E	1.5" ORIGINIAL AC SURFACE
4 - D	8" AC BINDER
3 - C	15" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

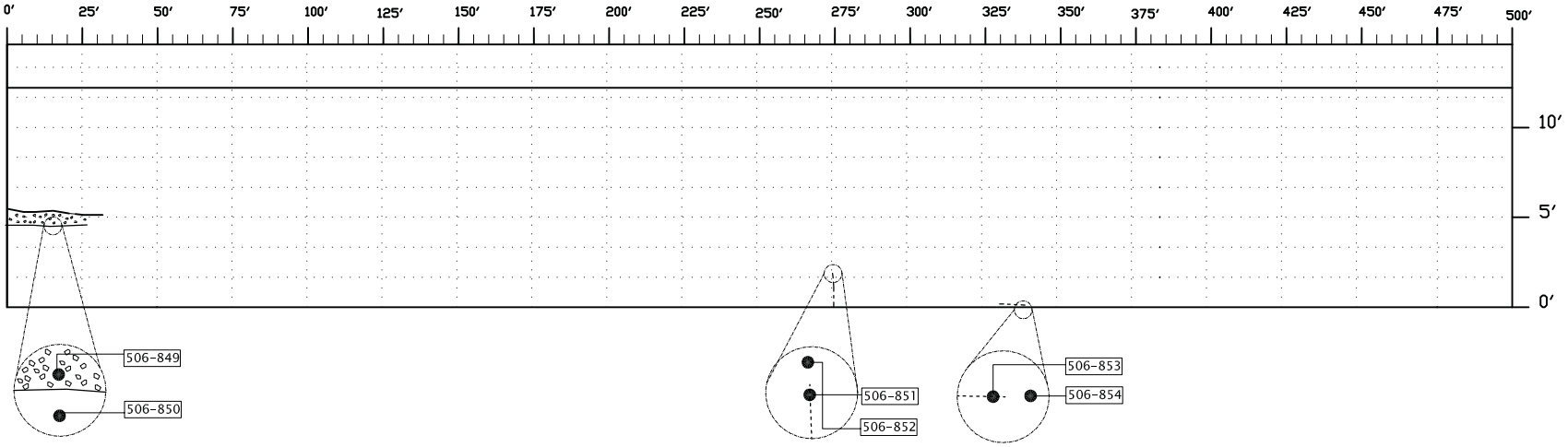
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A505

SECTION: 48_A506



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
506-849	RAVELING	4" DIA	15+00, 06+00
506-850	REPLICATE CORE NEAR RAVELING	4" DIA	15+00, 05+60
506-851	REFLECTED TRANSVERSE CRACKING	4" DIA	275+00, 02+00
506-852	REPLICATE CORE NEAR TRANSVERSE CRACKING	4" DIA	275+00, 02+40
506-853	REFLECTED LONGITUDINAL CRACKING	4" DIA	344+00, 0+00
506-854	REPLICATE CORE NEAR LONGITUDINAL CRACKING	4" DIA	344+40, 0+00

LAYER CODE	LAYER DESCRIPTION
7 - I	2.3" AC OVERLAY - VIRGIN
6 - H	1.6" AC OVERLAY BINDER- VIRGIN
5 - E	ORIGINIAL AC SURFACE-MILLED
4 - D	7.7" AC BINDER
3 - C	15" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

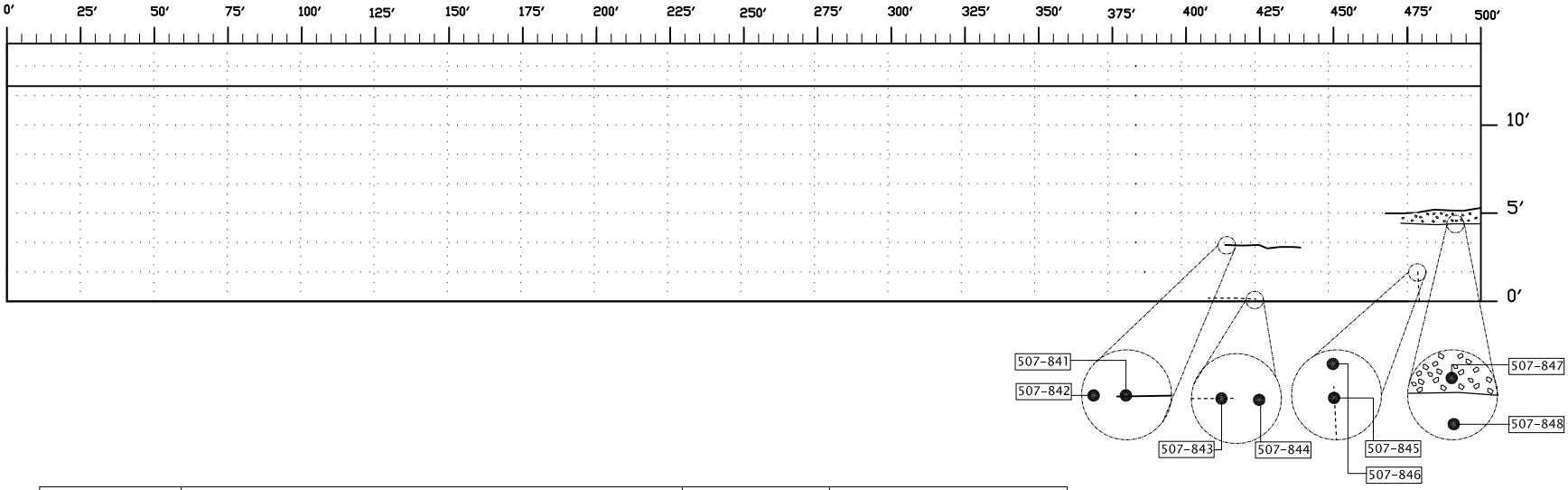
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A506

SECTION: 48_A507



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
507-841	FATIGUE CRACKING	4" DIA	415+00, 03+00
507-842	REPLICATE CORE NEAR FATIGUE CRACKING	4" DIA	415+00, 03+00
507-843	REFLECTED LONGITUDINAL CRACKING	4" DIA	425+00, 0+00
507-844	REPLICATE CORE NEAR LONGITUDINAL CRACKING	4" DIA	425+40, 0+00
507-845	REFLECTED TRANSVERSE CRACKING	4" DIA	450+00, 02+00
507-846	REPLICATE CORE NEAR TRANSVERSE CRACKING	4" DIA	450+00, 01+60
507-847	RAVELING	4" DIA	495+00, 05+00
507-848	REPLICATE CORE NEAR RAVELING	4" DIA	490+40, 04+60

LAYER CODE	LAYER DESCRIPTION
7 - I	2.0" AC OVERLAY - VIRGIN
6 - H	5.0" AC OVERLAY BINDER- VIRGIN
5 - E	ORIGINIAL AC SURFACE - MILLED
4 - D	7.7" AC BINDER
3 - C	15" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

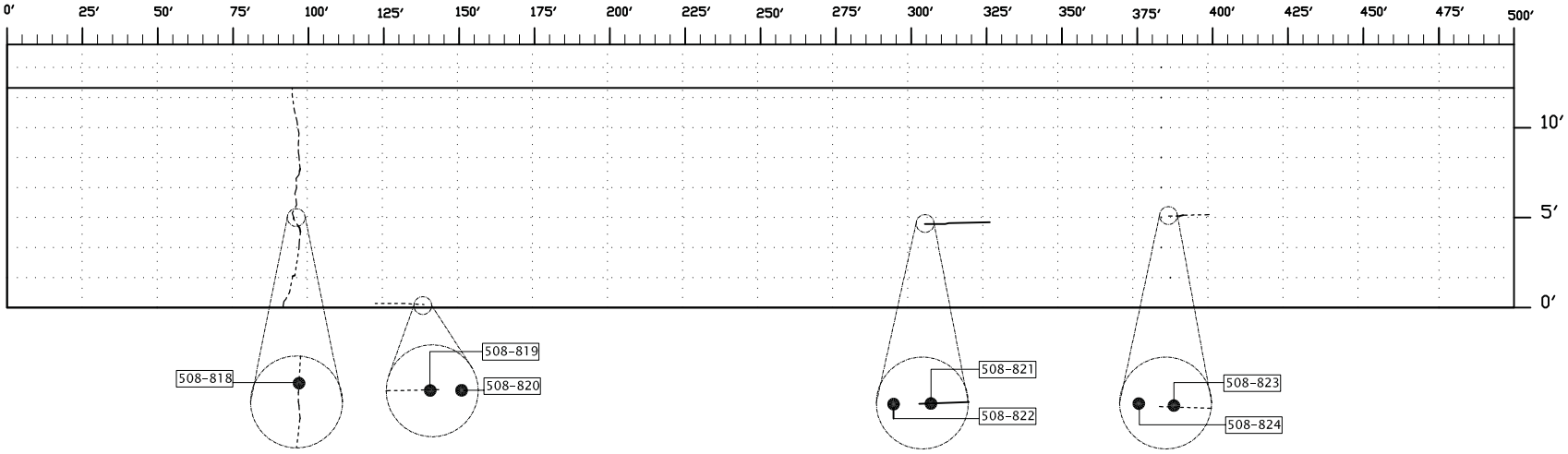
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A507

SECTION: 48_A508



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
508-818	REFLECTED TRANSVERSE CRACKING	4" DIA	95+00, 05+00
508-819	REFLECTED LONGITUDINAL CRACKING	4" DIA	375+00, 0+00
508-820	REPLICATE CORE NEAR THE LONGITUDINAL CRACKING	4" DIA	375+50, 0+00
508-821	FATIGUE CRACKING	4" DIA	310+00, 05+00
508-822	REPLICATE CORE NEAR FATIGUE CRACKING	4" DIA	309+50, 05+00
508-823	REFLECTIVE LONGITUDINAL CRACKING	4" DIA	385+00, 05+00
508-824	REPLICATE CORE NEAR LONGITUDINAL CRACKING	4" DIA	384+50, 05+00

LAYER CODE	LAYER DESCRIPTION
7 - G	2.1" AC OVERLAY - RAP
6 - F	5.2" AC OVERLAY BINDER- RAP
5 - E	ORIGINIAL AC SURFACE - MILLED
4 - D	8.3" AC BINDER
3 - C	14" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

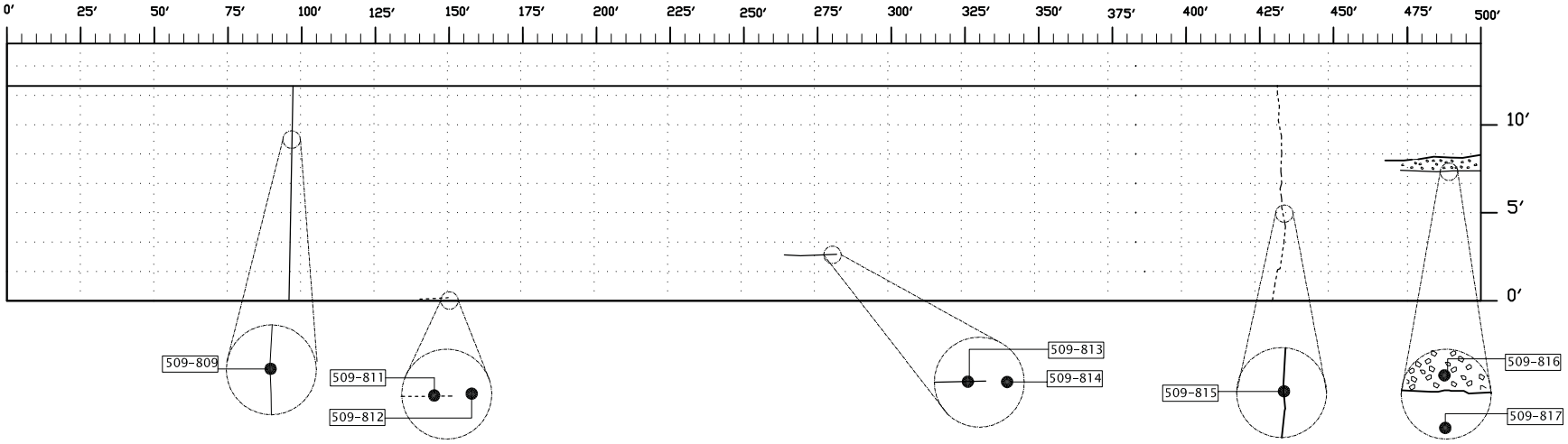
PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :
THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A508

SECTION: 48_A509



CORE #	REASON INVESTIGATED	CORE DIMENSION	CORE LOCATION
509-809	TRANSVERSE CRACKING REFLECTED	4" DIA	100+00, 06+00
509-811	REFLECTED LONGITUDINAL CRACKING	4" DIA	150+00, 0+00
509-812	REPLICATE CORE NEAR LONGITUDINAL CRACKING	4" DIA	150+50, 0+00
509-813	FATIGUE CRACKING	4" DIA	310+00, 05+00
509-814	REPLICATE CORE NEAR FATIGUE CRACKING	4" DIA	310+50, 5+00
509-815	REFLECTED TRANSVERSE CRACKING	4" DIA	430+00, 05+00
509-816	RAVELING	4" DIA	480+00, 08+00
509-817	REPLICATE CORE NEAR RAVELING	4" DIA	490+00, 05+00

LAYER CODE	LAYER DESCRIPTION
7 -G	2.2" AC OVERLAY - RAP
6 - F	2.1" AC OVERLAY BINDER- RAP
5 - E	ORIGINIAL AC SURFACE - MILLED
4 - D	7.8" AC BINDER
3 - C	14" LIME STABILIZED CSB
2 - B	8" LTS
1 - A	FAT CLAY

FHWA-LTPP-SPS-5 FORENSIC STUDY

CORE LOCATION DRAWINGS

PROJECT LOCATION: US 175 EB KAUFMAN COUNTY, TX

NOTE :

THESE ARE NOT CONSTRUCTION DRAWINGS AND NOT DRAWN TO SCALE

DATE: 09/09/2008

SECTION: A509

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5633_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A502				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	502-801				
BORE LOCATION CODE	CA-801	STATION NO	15+00, 06+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	Steve Davis	EQUIPMENT	SIMCO
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ No				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity		

CRACK PATTERN: N/A

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) *Longitudinal Crack(not reflected)*

Other Notes : *Reflected crack below not located precicely over the reflective cracking on the original pavement per the PASCO surve*

No cracks observed but original AC binder (layer D) was noted to be deteriorated especially at the joint with original AC surface (layer E

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☑ Yes	☐ No
D	7.50	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 11.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5636_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A502*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*502-802*				
BORE LOCATION CODE	*CA-802*	STATION NO	*170+20, 3+00*	WP/ NWP	*WP*
CORING DATE	*10-Sep-08*	OPERATOR	*Steve Davis*	EQUIPMENT	*SIMCO*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity

CRACK PATTERN: N/A (Non cracked replicate of CA-803)

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Stripping noted on wheel path.*

Original AC binder (layer D) was noted to be deteriorated and crumbled while core is collecte

CORE LAYER DATA (FROM TOP TO BOTTOM):

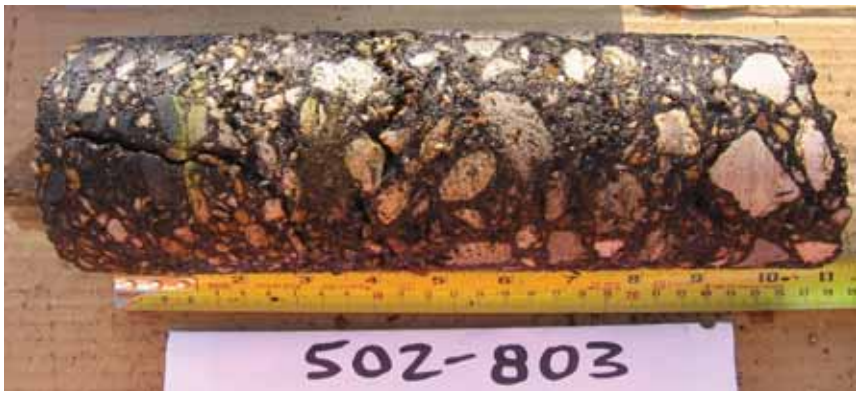
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*1.75*	*Overlay - RAP*	☑ Yes	☐ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	*7.50*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *10.75*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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CORING LOG

STATE CODE	48				
SHRP ID	A502				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	502-803				
BORE LOCATION CODE	CA-803	STATION NO	170+20, 4+00	WP/ NWP	WP
CORING DATE	10-Sep-08	OPERATOR	Steve Davis	EQUIPMENT	SIMCO
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset ____ ☐ After Section	Offset ____
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Bottom of Layer E

Crack Depth (inches): 3.0 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Fatigue Cracking

Other Notes : Fatigue crack noted on the surface not extended to the base
Original AC binder (layer D) was noted to be deteriorated

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☑ Yes	☐ No
D	7.50	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 11.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: ____ — Employer: ____ — Date: ____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5639_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A502*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*502-804*				
BORE LOCATION CODE	*CA-804*	STATION NO	*248+00, 4+00*	WP/ NWP	*WP*
CORING DATE	*10-Sep-08*	OPERATOR	*Steve Davis*	EQUIPMENT	*SIMCO*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No		
Cracked through	☐ Aggregate	☑ Binder	☐ Both	
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	

Layer of Crack Origin: *Mid of Layer D* — If Applicable, Layer where cracking stopped: *Top of Layer G*

Crack Depth (inches): *5.5* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Transverse Crack*

Other Notes : *Crack source noted to be original base (Layer D)and seem to be extended to the top of the layer*

Original AC binder (layer D) was noted to be deteriorated and cracked

CORE LAYER DATA (FROM TOP TO BOTTOM):

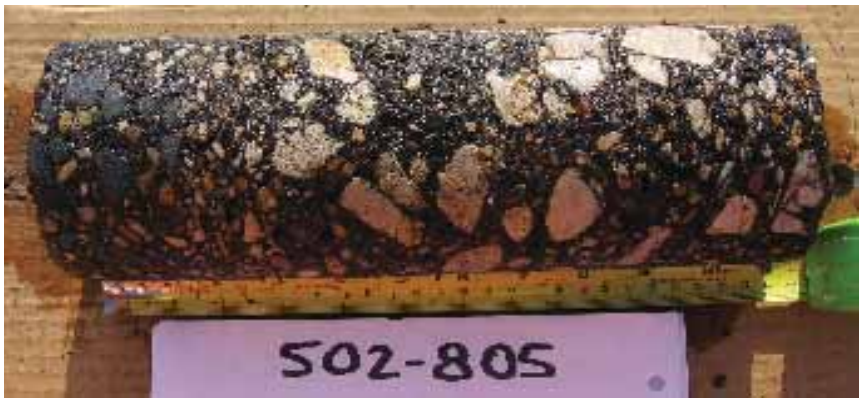
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*1.75*	*Overlay - RAP*	☐ Yes	☑ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	*7.50*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *10.75*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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CORING LOG

STATE CODE	*48*				
SHRP ID	*A502*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*502-805*				
BORE LOCATION CODE	*CA-805*	STATION NO	*248+00, 3+00*	WP/ NWP	*WP*
CORING DATE	*10-Sep-08*	OPERATOR	*Steve Davis*	EQUIPMENT	*SIMCO*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity		

CRACK PATTERN: N/A (Non cracked replicate of CA-804)

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *No cracks noted on the surface but the original AC binder is noted to have some crack development probably due to deterioration*

CORE LAYER DATA (FROM TOP TO BOTTOM):

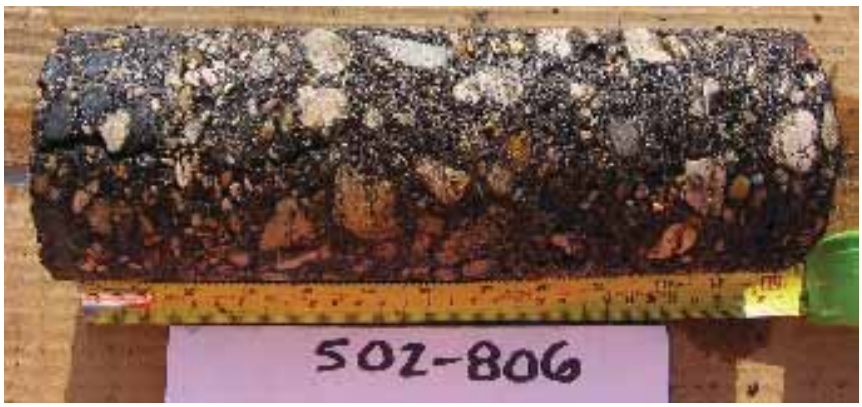
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*1.75*	*Overlay - RAP*	☐ Yes	☑ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	*8.00*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *11.25*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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CORING LOG

STATE CODE	48				
SHRP ID	A502				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	502-806				
BORE LOCATION CODE	CA-806	STATION NO	465+00, 8+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	Steve Davis	EQUIPMENT	SIMCO
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation		☐ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Layer G top — If Applicable, Layer where cracking stopped: Layer D mid

Crack Depth (inches): 5.0 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal Crack

Other Notes : Crack source is noted to be the Overlay Surface (Layer G) and extending to the mid of the base layer where it is mostly deteriorated

CORE LAYER DATA (FROM TOP TO BOTTOM):

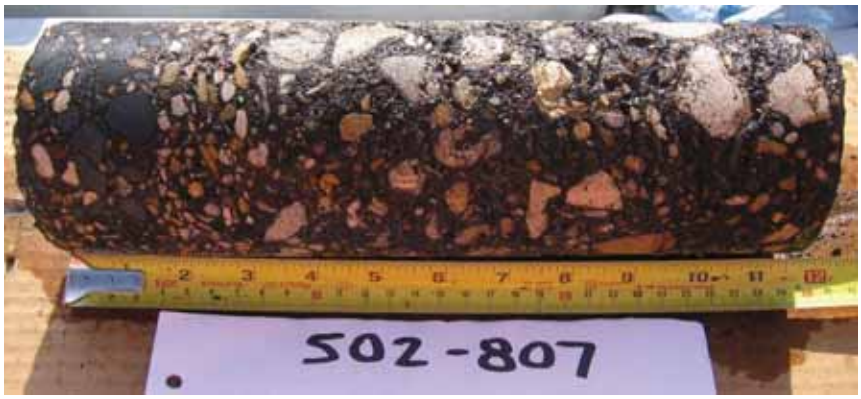
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?
G	1.75	Overlay - RAP	☐ Yes ☑ No
E	1.50	Original AC Surface	☑ Yes ☐ No
D	8.50	Original AC Binder	☑ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No

Total Core Thickness: 11.75

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:____IMG_5646_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A502*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*502-807*				
BORE LOCATION CODE	*CA-807*	STATION NO	*464+06, 8+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*Steve Davis*	EQUIPMENT	*SIMCO*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset	☐ After Section	Offset	
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity		

CRACK PATTERN: NA (Non cracked replicate of CA-806)

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *This replicate core near the cracked core 502_806 is observed to have no crack development in any of the layers except th*

Original AC Base and Surface (Layer D and E) has deteriorated to a greater extend

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*1.75*	*Overlay - RAP*	☐ Yes	☑ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	*8.50*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *11.75*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_503_825_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A503*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*503-825*				
BORE LOCATION CODE	*CA-825*	STATION NO	*06+00, 4+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No		
Cracked through	☐ Aggregate	☑ Binder	☐ Both	
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	_____

Layer of Crack Origin: *Mid of Layer D* — If Applicable, Layer where cracking stopped: *Top of layer G*

Crack Depth (inches): *7.0* — Crack Width (inches): *1/2* — Distress Type (Table A.22): *Fatigue*

Other Notes : *Fatigue crack at this location is noted in the PASCO survey in 1991 and reflected to the overlay surface*

Seggregation of larger aggregated on the top of the layer noted in the deteriorated Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*2.00*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*3.20*	*Overlay AC Binder - RAP*	☐ Yes	☑ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	8.00	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *14.70*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5581_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-826				
BORE LOCATION CODE	CA-826	STATION NO	06+50, 4+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Replicate core for 503_825 doesn't indicate any crack development in any layers*

But the Original AC Surface (Layer E) is found to be highly deteriorated

Seggregation of larger aggregated on the top of the layer noted in the deteriorated Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.20	Overlay AC Binder - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☑ Yes	☐ No
D	5.00	Original AC Binder	☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 11.70

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5583_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-827				
BORE LOCATION CODE	CA-827	STATION NO	74+00, 6+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Original AC Base (layer D) and Surface (Layer E) are not recovered at this location where there is both transverse and longitudinal crack reported in PASCO survey. It is noted that these crackings are not reflected through the overla*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.20	Overlay AC Binder - RAP	☐ Yes	☑ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 5.20

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5585_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-828				
BORE LOCATION CODE	CA-828	STATION NO	100+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Layer G

Crack Depth (inches): 0.5 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Longitudinal crack located at this location was found to be extending from the pavement edge marking to the surface layer

General deterioration of Original AC Base (Layer D) observed

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.20	Overlay AC Binder - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 14.70

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5592_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-828B				
BORE LOCATION CODE	CA-828B	STATION NO	365+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Bottom of Layer F

Crack Depth (inches): 5.0 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Longitudinal crack located at this location was found to be extending from the pavement edge marking

General deterioration of Original AC Base (Layer D) observed

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.50	Overlay AC Binder - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 14.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5587_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A503*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*503-829*				
BORE LOCATION CODE	*CA-829*	STATION NO	*100+40, 0+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____		
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity			

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Top of Layer G* — If Applicable, Layer where cracking stopped: *Layer G*

Crack Depth (inches): *0.25* — Crack Width (inches): *1/16* — Distress Type (Table A.22): *Longitudinal*

Other Notes : *Replicate core for 503_828 for longitudinal crack was found to follow the trend of developing a crack at the top surfac*

General deterioration of Original AC Base (Layer D) observed

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*2.00*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*3.20*	*Overlay AC Binder - RAP*	☐ Yes	☑ No
E	*1.50*	*Original AC Surface*	☐ Yes	☑ No
D	8.00	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *14.70*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

LTPP

Digital Camera Filename:_____IMG_5595_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-829B				
BORE LOCATION CODE	CA-829B	STATION NO	365+40, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Replicate core for 503_828 for longitudinal crack didn't show development of cracks in any layer*

General deterioration of Original AC Base (Layer D) observed

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.20	Overlay AC Binder - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 14.70

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

CORING LOG

Digital Camera Filename:_____IMG_5589_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

STATE CODE	*48*				
SHRP ID	*A503*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*503-830*				
BORE LOCATION CODE	*CA-830*	STATION NO	*210+00, 5+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No		
Cracked through	☐ Aggregate	☐ Binder	☐ Both	
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	_____

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) *Transverse*

Other Notes : *Transverse crack at this location was noted on existing pavement in the 1991 PASCO survey and not reflected trough the overlay Binder and Surface. Since the portion of Original Surface (Layer E) and Base (Layer D) was highly deteriorated this portion could not be recovered*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*2.00*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*2.00*	*Overlay AC Binder - RAP*	☑ Yes	☐ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	7.50	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *13.00*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5591_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A503*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*503-831*				
BORE LOCATION CODE	*CA-831*	STATION NO	*210+00, 4+60*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No		
Cracked through	☐ Aggregate	☐ Binder	☐ Both	
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	_____

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) *Transverse*

Other Notes : *Replicate core for 503_830 indicate the deteriorated original AC surface (Layer E) and Base (layer D,*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*2.00*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*2.00*	*Overlay AC Binder - RAP*	☑ Yes	☐ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	8.00	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *13.50*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5596_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-832				
BORE LOCATION CODE	CA-832	STATION NO	425+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____ ☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Bottom of Layer G

Crack Depth (inches): 2.00 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Longitudinal crack located at this location was found to be developed at the surface layer

General deterioration of Original AC Base (Layer D) observed

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.20	Overlay AC Binder - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
C	1.50	Lime Stabilized CSB	☐ Yes	☑ No
			☐ Yes	☐ No

Total Core Thickness: 16.20

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5599_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A503				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	503-833				
BORE LOCATION CODE	CA-833	STATION NO	425+40, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Replicate core for 503_832 doesn't show crack development in any of the layers.*

But it is observed that the cracks in the deterioration of Original AC Surface (layer E) and Base (Layer D) is not reflected to through the overla

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.20	Overlay AC Binder - RAP	☐ Yes	☑ No
E	1.50	Original AC Surface	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
C	1.50	Lime Stabilized CSB	☐ Yes	☑ No
			☐ Yes	☐ No

Total Core Thickness 16.20

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5600_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A504*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*504-834*				
BORE LOCATION CODE	*CA-834*	STATION NO	*65+00, 0+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Top of layer I* — If Applicable, Layer where cracking stopped: *Layer I bottom*

Crack Depth (inches): *2.0* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Longitudinal*

Other Notes :

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	*2.00*	*Overlay AC Surface - VIRGIN*	☐ Yes	☑ No
H	*3.00*	*Overlay AC Binder - VIRGIN*	☐ Yes	☑ No
E	*1.50*	*Original AC Surface*	☑ Yes	☐ No
D	4.50	*Original AC Base*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *11.00*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5602_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A504				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	504-835				
BORE LOCATION CODE	CA-835	STATION NO	65+40, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☑ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer I — If Applicable, Layer where cracking stopped: Layer I

Crack Depth (inches): 0.25 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Replicate core for 504_834 show similar crack pattern of top down cracking and it is observed that the existing cracks in Origina AC Base and Surface is not reflected through the overlay

General deterioration of the Original Base (Layer D) and Surface (Layer E) is obvious

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	3.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
E	1.50	Original AC Surface	☑ Yes	☐ No
D	7.50	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 14.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5605_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A504				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	504-836				
BORE LOCATION CODE	CA-836	STATION NO	175+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Mid of Layer D* — If Applicable, Layer where cracking stopped: *Top of Layer D*

Crack Depth (inches): *2.5* — Crack Width (inches): *1/2* — Distress Type (Table A.22): *Longitudinal*

Other Notes : *Crack identified on the original AC surface and base is not reflected through the overlay binder and surface laye*

General deterioration of the Original Base (Layer D) and Surface (Layer E) is obvious

CORE LAYER DATA (FROM TOP TO BOTTOM):

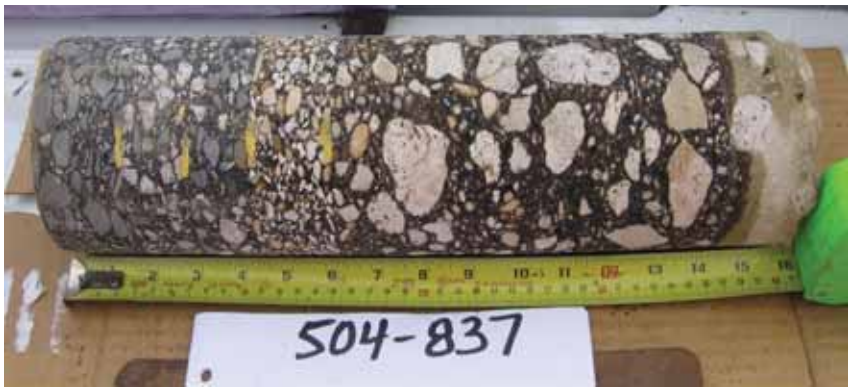
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	2.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
E	1.20	Original AC Surface	☑ Yes	☐ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *13.95*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:_____IMG_5609_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A504				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	504-837				
BORE LOCATION CODE	CA-837	STATION NO	230+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Crack identified on the original AC surface and base is not reflected through the overlay binder and surface laye*

General deterioration of the Original Base (Layer D) and Surface (Layer E) is obvious

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	1.75	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	3.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
E	1.30	Original AC Surface	☑ Yes	☐ No
D	8.50	Original AC Base	☑ Yes	☐ No
C	1.50	Lime Stabilized CSB	☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 16.05

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

CORING LOG

Digital Camera Filename:_____IMG_5606_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

STATE CODE	48				
SHRP ID	A504				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	504-838				
BORE LOCATION CODE	CA-838	STATION NO	229+60, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset	
Core Matrix Irregularity	☐ Stripping	☑ Voids	☐ Seggregation		☑ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No		
Cracked through	☐ Aggregate	☐ Binder	☐ Both	
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Replicate core for 504_837 doesn't show any crack on the original AC surface or base though it is greatly deteriorate*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	3.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
E	1.30	Original AC Surface	☑ Yes	☐ No
D	8.50	Original AC Base	☑ Yes	☐ No
C	1.50	Lime Stabilized CSB	☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 16.30

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5611_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A504				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	504-839				
BORE LOCATION CODE	CA-839	STATION NO	299+00, 2+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No		
Cracked through	☐ Aggregate	☑ Binder	☐ Both	
Crack Direction	☑ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth	

Layer of Crack Origin: Top of Layer I — If Applicable, Layer where cracking stopped: Layer I bottom

Crack Depth (inches): 2.0 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Transverse Crack

Other Notes : Transverse crack noted in PASCO survey of 1991 not located on the original AC surface or base.

But transverse crack observed on the overlay surface is noted to develop recently at the surface layer and extending down

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	3.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
E	1.30	Original AC Surface	☑ Yes	☐ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 14.30

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5613_____
Location Stored:__Forensic Study_48A5\Camera2\156CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A504				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	504-840				
BORE LOCATION CODE	CA-840	STATION NO	299+00, 2+40	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Overlay is identified to be in perfect condition though the original surface and base is found to be highly deteriorate*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	3.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
E	1.25	Original AC Surface	☑ Yes	☐ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 14.25

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5660_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-855				
BORE LOCATION CODE	CA-855	STATION NO	5+60, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Layer D* — If Applicable, Layer where cracking stopped: *Top of Layer I*

Crack Depth (inches): *4.0* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Transverse Crack*

Other Notes :

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

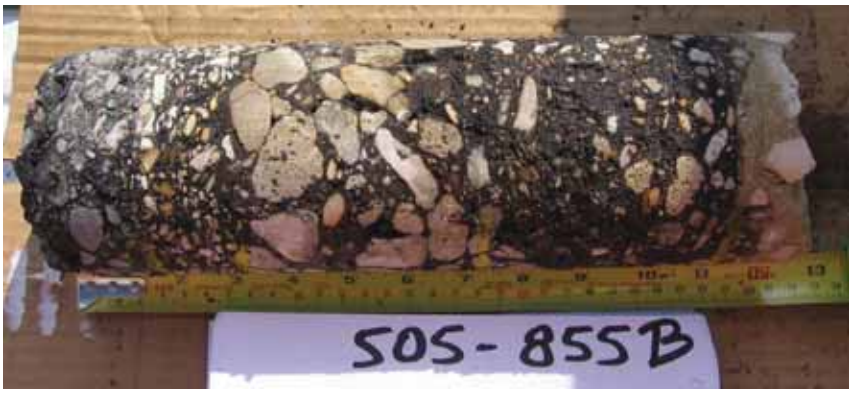
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	*2.00*	*Overlay AC Surface - VIRGIN*	☐ Yes	☑ No
H	*1.50*	*Overlay AC Binder - VIRGIN*	☐ Yes	☑ No
D	*7.75*	*Original AC Base*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *11.25*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:_____IMG_5661_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	505-855B				
BORE LOCATION CODE	CA-855B	STATION NO	6+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No		
Cracked through	☐ Aggregate	☑ Binder	☐ Both	
Crack Direction	☑ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	

Layer of Crack Origin: Mid of Layer D — If Applicable, Layer where cracking stopped: Top of Layer D

Crack Depth (inches): 5.0 — Crack Width (inches): 1/16 — Distress Type (Table A.22): _____

Other Notes : crack in original base not reflected to through overlay

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

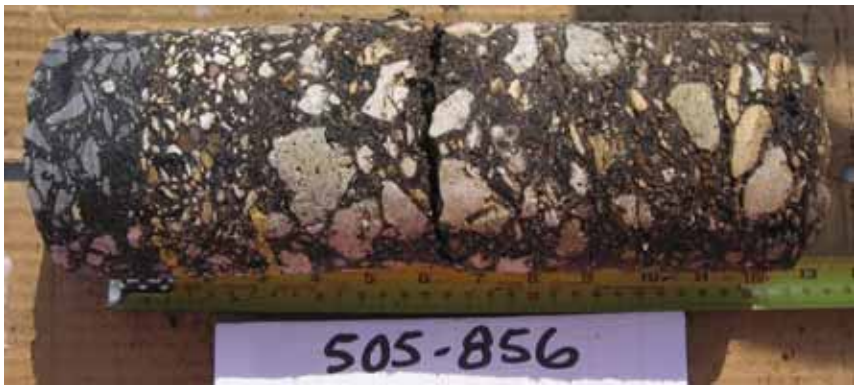
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
C	1.25	Lime Stabilized CSB	☐ Yes	☑ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 13.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	505-856				
BORE LOCATION CODE	CA-856	STATION NO	150+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Crack identified per the 1991 PASCO survey in the original Base not located while boring*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 11.75

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5666_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	505-857				
BORE LOCATION CODE	CA-857	STATION NO	220+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☐ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Layer D — If Applicable, Layer where cracking stopped: Layer I

Crack Depth (inches): 6.0 — Crack Width (inches): 2/8 — Distress Type (Table A.22): Longitudinal Crack

Other Notes : Existing crack reflected through overlay

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 11.75

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5668_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	505-858				
BORE LOCATION CODE	CA-858	STATION NO	220+40, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Mid of Layer D* — If Applicable, Layer where cracking stopped: *Top of Layer I*

Crack Depth (inches): *6.0* — Crack Width (inches): *2/8* — Distress Type (Table A.22): *Longitudinal Crack*

Other Notes : *Existing crack growing through overlay*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	*2.00*	*Overlay AC Surface - VIRGIN*	☐ Yes	☑ No
H	*1.75*	*Overlay AC Binder - VIRGIN*	☐ Yes	☑ No
D	8.00	*Original AC Base*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *11.75*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5669_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	505-859				
BORE LOCATION CODE	CA-859	STATION NO	360+00, 6+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Layer D — If Applicable, Layer where cracking stopped: Layer I

Crack Depth (inches): 8.0 — Crack Width (inches): 2/8 — Distress Type (Table A.22): Transverse Crack

Other Notes : Crack reflecting through overlay

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.50	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
C	2.50	Lime Stabilized CSB	☐ Yes	☑ No
			☐ Yes	☐ No
			☐ Yes	☐ No

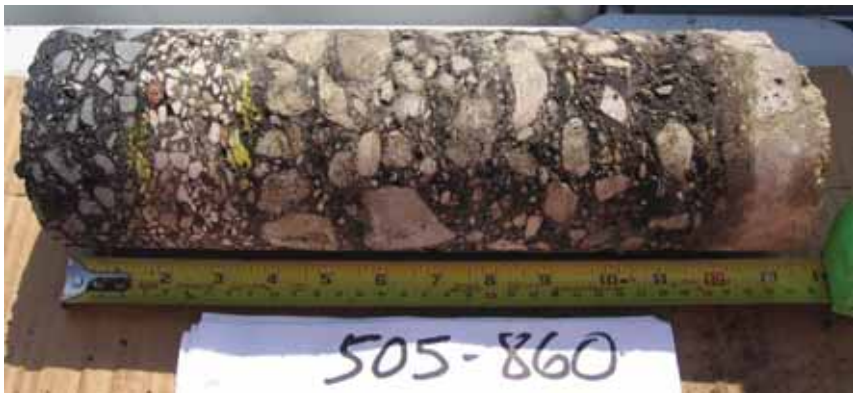
Total Core Thickness: 14.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

CORING LOG



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STATE CODE	48				
SHRP ID	A505				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	505-860				
BORE LOCATION CODE	CA-860	STATION NO	360+00, 6+40	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Mid of Layer D
If Applicable, Layer where cracking stopped: Layer I
Crack Depth (inches): 7.5
Crack Width (inches): 1/16
Distress Type (Table A.22): Transverse
Other Notes : Crack not reflected through overlay
General deterioration of original base and surfac

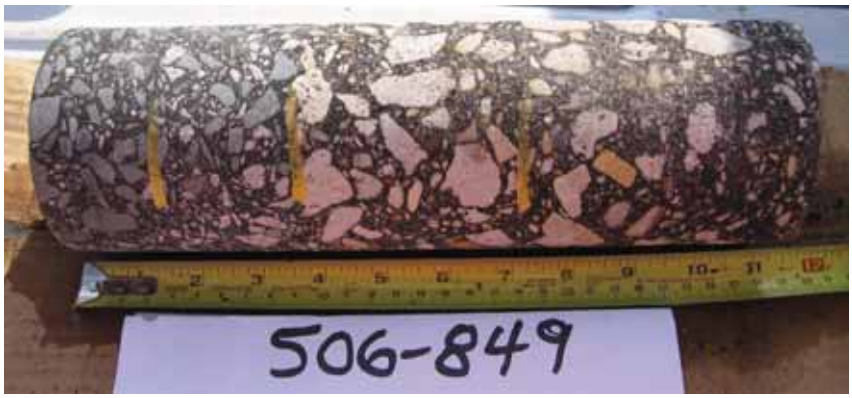
CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes ☑ No
H	1.50	Overlay AC Binder - VIRGIN	☐ Yes ☑ No
D	8.00	Original AC Base	☑ Yes ☐ No
C	2.00	Lime Stabilized CSB	☐ Yes ☑ No
			☐ Yes ☐ No
			☐ Yes ☐ No

Total Core Thickness: 13.50

Prepared By	Ruben	Employer	Fugro Consultants Inc	Date	10-Sep-08
Reviewed By		Employer		Date	

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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CORING LOG

STATE CODE	48				
SHRP ID	A506				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-849				
BORE LOCATION CODE	CA-849	STATION NO	15+00, 6+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes :

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

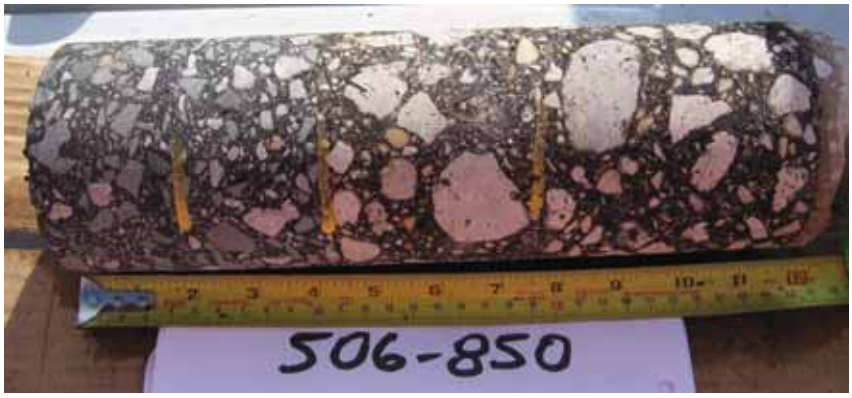
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.25	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.50	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.75	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 11.50

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A506				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-850				
BORE LOCATION CODE	CA-850	STATION NO	15+00, 5+60	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : Raveling less

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

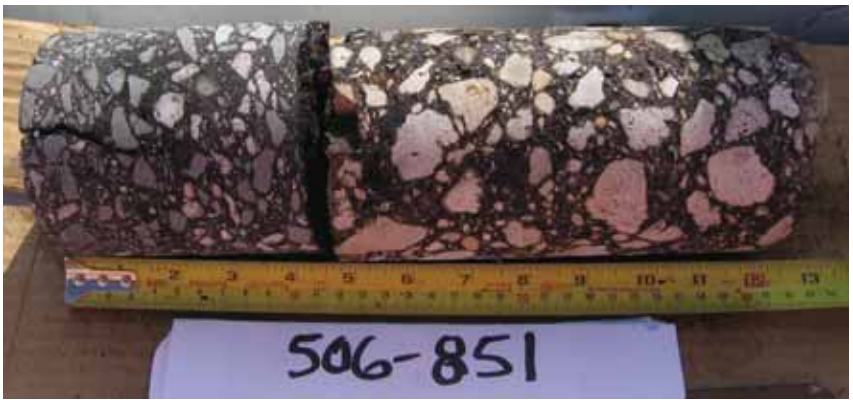
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.25	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 12.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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CORING LOG

STATE CODE	48				
SHRP ID	A506				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-851				
BORE LOCATION CODE	CA-851	STATION NO	275+00, 2+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☑ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top Layer I — If Applicable, Layer where cracking stopped: Bottom of Layer I

Crack Depth (inches): 2.25 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Transverse Crack

Other Notes : Top Down crack pattern

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

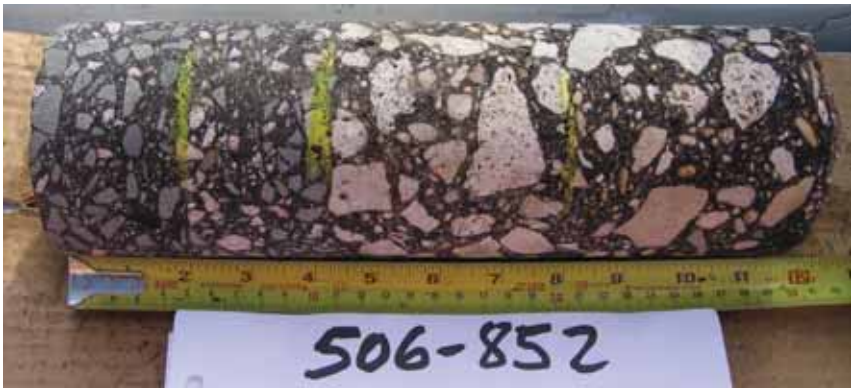
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.25	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 12.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:_____IMG_5654_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A506				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-852				
BORE LOCATION CODE	CA-852	STATION NO	275+00, 2+40	WP/ NWP	WP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : No cracking observed in any layers

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.25	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	1.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.75	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 11.75

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5655_____
Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A506				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-853				
BORE LOCATION CODE	CA-853	STATION NO	344+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer I — If Applicable, Layer where cracking stopped: Layer I

Crack Depth (inches): 1.00 — Crack Width (inches): 1/8 — Distress Type (Table A.22): _____

Other Notes : Top Down Cracking and crack in base layer not reflected through overly

General deterioration of original base and surface

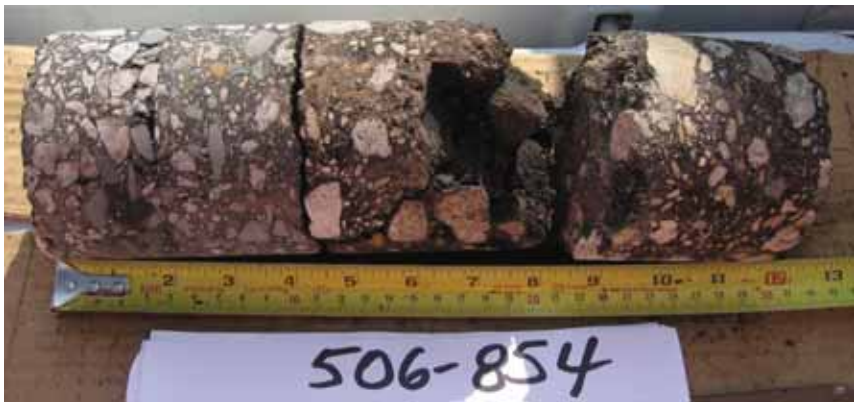
CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?
I	2.2.5	Overlay AC Surface - VIRGIN	☐ Yes ☑ No
H	1.50	Overlay AC Binder - VIRGIN	☐ Yes ☑ No
D	8.00	Original AC Base	☑ Yes ☐ No
C	1.25	Lime Stabilized CSB	☐ Yes ☑ No
			☐ Yes ☐ No
			☐ Yes ☐ No

Total Core Thickness: 10.75

Prepared By	Ruben	Employer	Fugro Consultants Inc	Date	10-Sep-08
Reviewed By		Employer		Date	

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



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Location Stored:__Forensic Study_48A5\Camera1\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A506				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	506-854				
BORE LOCATION CODE	CA-854	STATION NO	344+40, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Crack in base layer not reflected through overly*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	2.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	8.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☑ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 12.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5617_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A507				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	507-841				
BORE LOCATION CODE	CA-841	STATION NO	415+00, 3+00	WP/ NWP	WP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Top of layer I* — If Applicable, Layer where cracking stopped: *Layer I bottom*

Crack Depth (inches): *1.5* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Longitudinal*

Other Notes : *Top down dracking pattern observed*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	1.75	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	5.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.25	Original AC Base	☑ Yes	☐ No
			☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *14.00*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5614_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A507*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*507-842*				
BORE LOCATION CODE	*CA-842*	STATION NO	*414+00, 3+00*	WP/ NWP	*WP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Overlay in good condition*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	*1.75*	*Overlay AC Surface - VIRGIN*	☐ Yes	☑ No
H	*5.00*	*Overlay AC Binder - VIRGIN*	☐ Yes	☑ No
D	*7.25*	*Original AC Base*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *14.00*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5620_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A507				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	507-843				
BORE LOCATION CODE	CA-843	STATION NO	425+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer I — If Applicable, Layer where cracking stopped: Layer I

Crack Depth (inches): 0.25 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Longitudinal crack identified along the pavement edge marking is not extended down. Overlay in good condition

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	5.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	5.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 12.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5619_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A507				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	507-844				
BORE LOCATION CODE	CA-844	STATION NO	425+40, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Replicate core for 507_843 doesn't show crack development in any layers . Overlay in good condition*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.00	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	5.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.00	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 14.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5625_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A507				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	507-845				
BORE LOCATION CODE	CA-845	STATION NO	450+00, 2+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☑ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of layer I — If Applicable, Layer where cracking stopped: Bottom of Layer I

Crack Depth (inches): 2.2 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Transverse Crack

Other Notes : Top down Cracking

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	2.10	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	5.00	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.20	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 14.30

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5623_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A507*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*507-846*				
BORE LOCATION CODE	*CA-846*	STATION NO	*450+00, 1+60*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Overlay in good condition*

General deterioration of original base and surface

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	*2.10*	*Overlay AC Surface - VIRGIN*	☐ Yes	☑ No
H	*5.00*	*Overlay AC Binder - VIRGIN*	☐ Yes	☑ No
D	*7.75*	*Original AC Base*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *14.85*

Prepared By *Ruben* Employer *Fugro Consultants Inc* Date *10-Sep-08*

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5623_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A507				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	507-847				
BORE LOCATION CODE	CA-847	STATION NO	490+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) Raveling

Other Notes : Raveling is more at wheel path

Compaction difference of layer matrix observed between the core at wheel path and non-wheel patl

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	1.75	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	4.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.50	Original AC Base	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 14.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5623_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A507				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	507-848				
BORE LOCATION CODE	CA-848	STATION NO	490+00, 4+60	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No		
Cracked through	☐ Aggregate	☐ Binder	☐ Both	
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction	
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth	

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) Raveling

Other Notes : Raveling is more at wheel path

Compaction difference of layer matrix observed between the core at wheel path and non-wheel patl

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
I	1.75	Overlay AC Surface - VIRGIN	☐ Yes	☑ No
H	4.75	Overlay AC Binder - VIRGIN	☐ Yes	☑ No
D	7.50	Original AC Base	☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 14.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5566_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A508*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*508-818*				
BORE LOCATION CODE	*CA-818*	STATION NO	*95+00, 5+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☑ Yes	☐ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Mid of Layer D* — If Applicable, Layer where cracking stopped: *Top of Layer G*

Crack Depth (inches): *10.0* — Crack Width (inches): *1/2* — Distress Type (Table A.22): *Transverse Crack*

Other Notes : *Transverse crack developed in Original AC Base (layer D) was reported in PASCO survey in year 1991 and identified to be reflected through Overlay AC Binder (layer F) till Overlay AC Surface (layer G)*

Seggregation of larger aggregated on the top of the layer noted where it crumbled in the deteriorated Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*2.00*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*5.00*	*Overlay AC Binder - RAP*	☐ Yes	☑ No
D	*5.50*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *12.50*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5579_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A508				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	508-819				
BORE LOCATION CODE	CA-819	STATION NO	375+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Top of Layer G* — If Applicable, Layer where cracking stopped: *Layer F*

Crack Depth (inches): *3.0* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Longitudinal*

Other Notes : *Longitudinal Crack observed at this location is along the pavement edge markings*

General deterioration and seggregation of coarse aggregates noted for Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	5.20	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.30	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *15.50*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5577_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A508				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	508-820				
BORE LOCATION CODE	CA-820	STATION NO	375+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Longitudinal Crack observed at this location is only with the pavement edge markings*

General deterioration and seggregation of coarse aggregates noted for Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

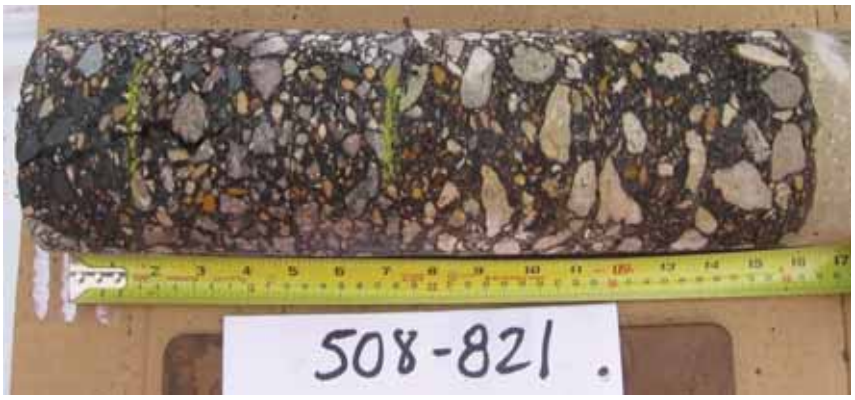
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	5.20	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.30	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 15.50

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:_____IMG_5570_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A508				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	508-821				
BORE LOCATION CODE	CA-821	STATION NO	310+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Mid Layer F

Crack Depth (inches): 4.5 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Longitudinal Crack observed at this location originated on the Overlay AC Surface (layer G) extended till mid Overlay AC Binder (layer F)

General deterioration and seggregation of coarse aggregates noted for Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

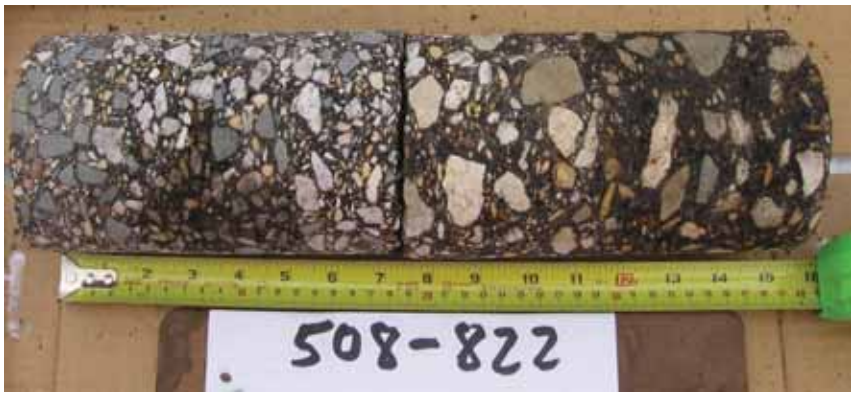
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	5.20	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.30	Original AC Binder	☑ Yes	☐ No
C	2.00	Lime Stabilized CSB	☐ Yes	☑ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 17.50

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:_____IMG_5568_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A508				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	508-822				
BORE LOCATION CODE	CA-822	STATION NO	309+50, 0+50	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *Compared to replicate core 508-821, there is no identifiation of cracks developing in any of the layers*

General deterioration and seggregation of coarse aggregates noted for Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	5.20	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.30	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 15.50

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5575_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A508				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	508-823				
BORE LOCATION CODE	CA-823	STATION NO	385+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered					
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation		☑ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No		
Cracked through	☐ Aggregate	☑ Binder	☐ Both	
Crack Direction	☐ Inclined	☐ Perpendicular	☑ No Pattern or multiple direction	
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth	

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Bottom of layer F

Crack Depth (inches): 5.0 — Crack Width (inches): 1/8 — Distress Type (Table A.22): Longitudinal

Other Notes : Longitudinal Crack observed at this location is assumed to be originated on the Overlay AC Surface (layer G) extended till bottom of Overlay AC Binder (layer F)since there is no cracks observed in the deteriorated Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

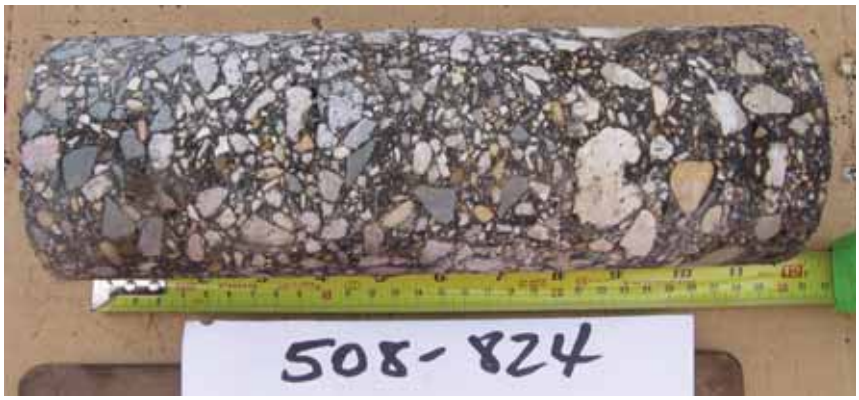
Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	3.00	Overlay AC Binder - RAP (Crumbled)	☐ Yes	☑ No
D	8.00	Original AC Binder	☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 13.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS



Digital Camera Filename:_____IMG_5572_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A508				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	508-824				
BORE LOCATION CODE	CA-824	STATION NO	384+50, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Top of Layer G — If Applicable, Layer where cracking stopped: Layer G

Crack Depth (inches): 0.25 — Crack Width (inches): 1/16 — Distress Type (Table A.22): Longitudinal

Other Notes : Compared to replicate core 508-823, there is some indication of cracks developing on the top of Overlay AC Surface (Layer G

General deterioration and seggregation of coarse aggregates noted for Original AC Base (layer D

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	5.20	Overlay AC Binder - RAP	☐ Yes	☑ No
D	4.50	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 11.70

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5551_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A509				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	509-809				
BORE LOCATION CODE	CA-809	STATION NO	100+00, 6+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer mounted drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ No				
Core Location	☑ On Section	☐ Before Section	Offset		☐ After Section	Offset
Core Matrix Irregularity	☐ Stripping	☐ Voids	☑ Seggregation *(In the Original AC Base)*		☐ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☑ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Layer F bottom*
If Applicable, Layer where cracking stopped: *Layer G top*
Crack Depth (inches): 4"
Crack Width (inches): 2/8
Distress Type (Table A.22): *Longitudinal*
Other Notes : *Longitudinal crack seemed to be developed from top and continued till bottom of the Overlay AC Binder (Layer F)*

Seggregation of the aggregates at the Original AC Base (Layer D) has caused the core to crumble at the point where there is dense coarse aggregate

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.00	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 12.00

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08
Reviewed By: — Employer: — Date:

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5554_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A509				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	509-811				
BORE LOCATION CODE	CA-811	STATION NO	150+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: Mid of Layer D — If Applicable, Layer where cracking stopped: Top of Layer G

Crack Depth (inches): 9.0 — Crack Width (inches): 1/2 — Distress Type (Table A.22): Longitudinal

Other Notes : Seggregation noted in the deteriorated Original AC Base (layer D)

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.00	Overlay AC Binder - RAP	☐ Yes	☑ No
D	7.50	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: 11.50

Prepared By: Ruben — Employer: Fugro Consultants Inc — Date: 10-Sep-08

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5555_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A509				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	509-812				
BORE LOCATION CODE	CA-812	STATION NO	151+00, 0+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Bottom of Layer F* — If Applicable, Layer where cracking stopped: *Top of Layer G*

Crack Depth (inches): *4.3* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Longitudinal*

Other Notes : *General deterioration and seggregation noted in the Original AC Base (layer D) and crack development noted in bottom of layer F to top of layer G that correlates with the replicate core 509-811 where there is severe crack originated from Original AC Base (Layer D*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.00	Overlay AC Binder - RAP	☐ Yes	☑ No
D	7.50	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *11.50*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5557_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A509*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*509-813*				
BORE LOCATION CODE	*CA-813*	STATION NO	*310+00, 5+00*	WP/ NWP	*NWP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity		

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☑ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Layer G top* — If Applicable, Layer where cracking stopped: *Layer F bottom*

Crack Depth (inches): *4.0* — Crack Width (inches): *1/8* — Distress Type (Table A.22): *Longitudinal*

Other Notes : *Clearly shows that this longitudinal crack is developed on the Overlay AC Surface*

Seggregation noted in the deteriorated Original AC Base (layer D)

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*2.00*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*2.00*	*Overlay AC Binder - RAP*	☐ Yes	☑ No
D	*8.00*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *12.00*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5558_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A509				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	509-814				
BORE LOCATION CODE	CA-814	STATION NO	310+50, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *General deterioration and seggregation noted in the Original AC Base (layer D,*

But no crack development noted in any of the layers to correlate with the replicate core 509-813 where there crack originated in Overlay AC

Surface (Layer G) extended till Original AC Base (Layer D)

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.00	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 12.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:____IMG_5561_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A509				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	509-815				
BORE LOCATION CODE	CA-815	STATION NO	430+00, 5+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered			
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____
Core Matrix Irregularity	☐ Stripping	☐ Voids	☐ Seggregation	☑ No Irregularity	

CRACK PATTERN:

Cracked Full Depth	☐ Yes	☑ No	
Cracked through	☐ Aggregate	☑ Binder	☐ Both
Crack Direction	☐ Inclined	☑ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☑ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin: *Layer D mid* — If Applicable, Layer where cracking stopped: *Layer G top*

Crack Depth (inches): *8.0* — Crack Width (inches): *2/8* — Distress Type (Table A.22): *Transverse*

Other Notes : *Transverse crack developed in Original AC Base (layer D) was reported in PASCO survey in year 1991 and identified to be reflected through Overlay AC Binder (layer F) till Overlay AC Surface (layer G) Seggregation of larger aggregated on the top of the layer noted where it crumbled in the deteriorated Original AC Base (layer D*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.00	Overlay AC Binder - RAP	☑ Yes	☐ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness: *12.00*

Prepared By: *Ruben* — Employer: *Fugro Consultants Inc* — Date: *10-Sep-08*

Reviewed By: _____ — Employer: _____ — Date: _____

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5562_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	*48*				
SHRP ID	*A509*				
HIGHWAY	*US 175*				
LANE DIRECTION	*EAST*				
BORE HOLE NO	*509-816*				
BORE LOCATION CODE	*CA-816*	STATION NO	*490+00, 9+00*	WP/ NWP	*WP*
CORING DATE	*10-Sep-08*	OPERATOR	*TXDOT*	EQUIPMENT	*Trailer Mounted Drill*
CORE BARREL SIZE (in)	*4"*	BARREL TIP TYPE	*Diamond*	COOLING MEDIUM	*Water*

CORE DATA:

Core Recovered	☑ Yes	☐ Not completely recovered				
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section	Offset _____	
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity		

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *General deterioration and seggregation noted in the Original AC Base (layer D)but no observations noted in any of these layers to correlate with the raveling on the Original AC Surface (Layer G) except the loading on wheel path that resulted in compacted matrix with less asphalt compared to replicate core at NWP*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	*1.75*	*Overlay AC Surface - RAP*	☐ Yes	☑ No
F	*2.00*	*Overlay AC Binder - RAP*	☐ Yes	☑ No
D	*8.00*	*Original AC Binder*	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness *11.75*

Prepared By	*Ruben*	Employer	*Fugro Consultants Inc*	Date	*10-Sep-08*
Reviewed By		Employer		Date	

FORENSIC INVESTIGATION PROJECT SPS-5 48A5 US 175, KAUFMAN, TEXAS

Digital Camera Filename:_____IMG_5565_____
Location Stored:__Forensic Study_48A5\Camera2\155CANON___

CORING LOG

STATE CODE	48				
SHRP ID	A509				
HIGHWAY	US 175				
LANE DIRECTION	EAST				
BORE HOLE NO	509-817				
BORE LOCATION CODE	CA-817	STATION NO	490+00, 8+00	WP/ NWP	NWP
CORING DATE	10-Sep-08	OPERATOR	TXDOT	EQUIPMENT	Trailer Mounted Drill
CORE BARREL SIZE (in)	4"	BARREL TIP TYPE	Diamond	COOLING MEDIUM	Water

CORE DATA:

Core Recovered	☐ Yes	☑ Not completely recovered		
Core Location	☑ On Section	☐ Before Section	Offset _____	☐ After Section Offset _____
Core Matrix Irregularity	☑ Stripping	☐ Voids	☐ Seggregation	☐ No Irregularity

CRACK PATTERN: NA

Cracked Full Depth	☐ Yes	☐ No	
Cracked through	☐ Aggregate	☐ Binder	☐ Both
Crack Direction	☐ Inclined	☐ Perpendicular	☐ No Pattern or multiple direction
Crack Mechanism	☐ Bottom Up	☐ Top Down	☐ Hairline cracks only on top <1/3 depth

Layer of Crack Origin _____ If Applicable, Layer where cracking stopped _____

Crack Depth (inches) _____ Crack Width (inches) _____ Distress Type (Table A.22) _____

Other Notes : *General deterioration and seggregation noted in the Original AC Base (layer D)but no observations noted in any of these layers to correlate with the raveling on the Original AC Surface (Layer G) of replicate core 509- 816 except the loading on wheel path that resulted in a more compacted matrix structure for the 509-816 core compared to 509-817*

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Code	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?	
G	2.00	Overlay AC Surface - RAP	☐ Yes	☑ No
F	2.00	Overlay AC Binder - RAP	☐ Yes	☑ No
D	8.00	Original AC Binder	☑ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

Total Core Thickness 12.00

Prepared By Ruben Employer Fugro Consultants Inc Date 10-Sep-08

Reviewed By _____ Employer _____ Date _____

Core Data					Crack Pattern									General Observations		
State Code	Section	Core ID	Recovered	Irregularity	Cracked full depth	Cracked through	Crack direction	Crack mechanism	Layer of crack origin	Layer crack stopped	Crack depth	Crack width	Distress Type	WP/ NWP	Layers Deteriorated	Pavement Edge
48	A502	807	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	E, D	
48	A502	806	Yes	Stripping	No	Binder	Perpendicular	Top Down	G top	D mid	5	1/8	Longitudinal	NWP	E, D	
48	A502	805	Yes	Stripping	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	E, D	
48	A502	804	Yes	Stripping	No	Binder	Perpendicular	Bottom Up	D mid	G top	5.5	1/8	Transverse	NWP	E, D	
48	A502	803	Yes	Stripping	No	Binder	Perpendicular	Top Down	G top	E bottom	3	1/8	Fatigue	WP	E, D	
48	A502	802	NCR*	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	G, E, D	
48	A502	801	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Non reflected	NWP	E, D	
48	A503	825	Yes	No	No	Binder	Perpendicular	Bottom Up	D mid	G top	7	1/2	Fatigue	WP	E, D	
48	A503	826	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	E	
48	A503	827	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Non reflected	NWP		
48	A503	828	Yes	No	No	Binder	Perpendicular	Top Down	G top	G	0.5	1/8	Longitudinal	NWP	D	EDGE
48	A503	829	Yes	No	No	Binder	Perpendicular	Top Down	G top	G	0.25	1/16	Long-Replicate	NWP	D	EDGE
48	A503	830	Yes	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Non Reflected	NWP	F, E, D	
48	A503	831	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	F, E, D	
48	A503	832	Yes	No	No	Binder	Perpendicular	Top Down	G top	G	2	1/8	Longitudinal	NWP	D	
48	A503	833	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	
48	A503	828B	Yes	No	No	Binder	Perpendicular	Top Down	G top	F bottom	5	1/8	Longitudinal	NWP	D	EDGE
48	A503	829B	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A504	834	NCR*	No	No	Binder	Perpendicular	Top Down	I top	I bottom	2	1/8	Longitudinal	NWP	E, D	EDGE
48	A504	835	NCR*	No	No	Binder	Perpendicular	Top Down	I top	I	0.25	1/8	Long-Replicate	NWP	E, D	EDGE
48	A504	836	NCR*	No	No	Binder	Perpendicular	Bottom Up	D mid	D top	2.5	1/2	Long-Non reflected	NWP	E, D	
48	A504	837	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling	WP	E, D	
48	A504	838	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling-Replicate	WP	E, D	
48	A504	839	NCR*	No	No	Binder	Inclined	Top Down	I top	I bottom	2	1/8	Transverse	NWP	E, D	EDGE
48	A504	840	NCR*	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	E, D	EDGE
48	A505	855	NCR*	No	No	Binder	Perpendicular	Bottom Up	D mid	I top	4	1/8	Transverse	WP	D	
48	A505	855B	Yes	No	No	Binder	Perpendicular	Bottom Up	D mid	D top	5	1/16	Trans-Replicate	WP	D	
48	A505	856	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Non Reflected	WP	D	

48	A505	857	NCR*	No	No	Binder	Perpendicular	Bottom Up	D mid	I	6	2/8	Longitudinal	NWP	D	EDGE
48	A505	858	NCR*	No	No	Binder	Perpendicular	Bottom Up	D	I top	6	2/8	Long-Replicate	NWP	D	EDGE
48	A505	859	NCR*	No	No	Binder	Perpendicular	Bottom Up	D mid	I top	8	2/8	Transverse	NWP	D	
48	A505	860	NCR*	No	No	Binder	Perpendicular	Bottom Up	D mid	I	7.5	1/16	Trans-Replicate	NWP	D	
48	A506	849	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling	NWP	D	
48	A506	850	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling-Replicate	NWP	D	
48	A506	851	NCR*	No	No	Binder	Inclined	Top Down	I top	I bottom	2.25	1/8	Transverse	NWP	D	EDGE
48	A506	852	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	D	EDGE
48	A506	853	NCR*	No	No	Binder	Perpendicular	Top Down	I top	I	1	1/8	Longitudinal	NWP	D	EDGE
48	A506	854	NCR*	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A507	841	NCR*	No	No	Binder	Perpendicular	Top Down	I top	I bottom	1.5	1/8	Fatigue	WP	D	
48	A507	842	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	D	
48	A507	843	NCR*	No	No	Binder	Perpendicular	Top Down	I top	I	0.25	1/8	Longitudinal	NWP	D	EDGE
48	A507	844	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A507	845	NCR*	No	No	Binder	Inclined	Top Down	I top	I bottom	2.2	1/8	Transverse	NWP	D	EDGE
48	A507	846	NCR*	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	D	EDGE
48	A507	847	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling	NWP	D	
48	A507	848	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling-Replicate	NWP	D	
48	A508	818	NCR*	No	Yes	Binder	Perpendicular	Bottom Up	D mid	G top	10	1/2	Trans-Reflected	NWP	D	
48	A508	819	Yes	No	No	Binder	Perpendicular	Top Down	G top	F top	3	1/8	Longitudinal	NWP	D	EDGE
48	A508	820	Yes	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A508	821	Yes	No	No	Binder	Perpendicular	Top Down	G top	F mid	4.5	1/8	Fatigue	WP	D	
48	A508	822	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	D	
48	A508	823	NCR*	No	No	Binder	Perpendicular	Top Down	G top	F bottom	5	1/8	Longitudinal	NWP	D	
48	A508	824	NCR*	No	No	Binder	Perpendicular	Top Down	G top	G	0.25	1/8	Long-Replicate	NWP	D	
48	A509	809	Yes	Stripping	No	Binder	Inclined	Bottom Up	F bottom	G top	4	2/8	Trans-Reflected	NWP	D	
48	A509	811	NCR*	N/A	No	Binder	Perpendicular	Bottom Up	D mid	G top	9	1/2	Longitudinal	NWP	D	EDGE
48	A509	812	Yes	No	No	Binder	Perpendicular	Bottom Up	F bottom	G top	4.3	1/8	Long-Replicate	NWP	D	EDGE
48	A509	813	Yes	Stripping	No	Binder	Perpendicular	Top Down	G top	F bottom	4	1/8	Fatigue	WP	D	
48	A509	814	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	D	
48	A509	815	Yes	No	No	Binder	Perpendicular	Bottom Up	D mid	G top	8	2/8	Trans-Reflected	NWP	F, D	
48	A509	816	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling	WP	D	
48	A509	817	NCR*	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Raveling-Replicate	WP	D	

** NCR Not Completely Recovered*

State Code	Section	Core ID	Recovered	Irregularity	Cracked full depth	Cracked through	Crack Direction	Crack Mechanism	Layer of crack origin	Layer crack stopped	Crack depth	Crack width	Distress Type	WP/NWP	Layers Deteriorated	Pavement Edge
48	A502	804	Yes	Stripping	No	Binder	Perpendicular	Bottom Up	D mid	G top	5.5	1/8	Transverse	NWP	E, D	
48	A502	805	Yes	Stripping	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	E, D	
48	A503	830	Yes	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Non Reflected	NWP	F, E, D	
48	A503	831	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	F, E, D	
48	A504	839	NCR	No	No	Binder	Inclined	Top Down	I top	I bottom	2	1/8	Transverse	NWP	E, D	EDGE
48	A504	840	NCR	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	E, D	EDGE
48	A505	855	NCR	No	No	Binder	Perpendicular	Bottom Up	D mid	I top	4	1/8	Transverse	WP	D	
48	A505	855B	Yes	No	No	Binder	Perpendicular	Bottom Up	D mid	D top	5	1/16	Trans-Replicate	WP	D	
48	A505	856	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Non Reflected	WP	D	
48	A505	859	NCR	No	No	Binder	Perpendicular	Bottom Up	D mid	I top	8	2/8	Transverse	NWP	D	
48	A505	860	NCR	No	No	Binder	Perpendicular	Bottom Up	D mid	I	7.5	1/16	Trans-Replicate	NWP	D	
48	A506	851	NCR	No	No	Binder	Inclined	Top Down	I top	I bottom	2.25	1/8	Transverse	NWP	D	EDGE
48	A506	852	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	D	EDGE
48	A507	845	NCR	No	No	Binder	Inclined	Top Down	I top	I bottom	2.2	1/8	Transverse	NWP	D	EDGE
48	A507	846	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Trans-Replicate	NWP	D	EDGE
48	A508	818	NCR	No	Yes	Binder	Perpendicular	Bottom Up	D mid	G top	10	1/2	Trans-Reflected	NWP	D	
48	A509	809	Yes	Stripping	No	Binder	Inclined	Bottom Up	F bottom	G top	4	2/8	Trans-Reflected	NWP	D	
48	A509	815	Yes	No	No	Binder	Perpendicular	Bottom Up	D mid	G top	8	2/8	Trans-Reflected	NWP	F, D	

Summary:

Crack Mechanism	Total	RAP		VIRGIN	
		Thin	Thick	Thin	Thick
Bottom up	8	3	1	4	
Top Down	3			2	1

State Code	Section	Core ID	Recovered	Irregularity	Cracked full depth	Cracked through	Crack Direction	Crack Mechanism	Layer of crack origin	Layer crack stopped	Crack depth	Crack width	Distress Type	WP / NWP	Layers Deteriorated	Pavement Edge
48	A502	806	Yes	Stripping	No	Binder	Perpendicular	Top Down	G top	D mid	5	1/8	Longitudinal	NWP	E, D	
48	A502	807	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	E, D	
48	A503	828	Yes	No	No	Binder	Perpendicular	Top Down	G top	G	0.5	1/8	Longitudinal	NWP	D	EDGE
48	A503	829	Yes	No	No	Binder	Perpendicular	Top Down	G top	G	0.25	1/16	Long-Replicate	NWP	D	EDGE
48	A503	832	Yes	No	No	Binder	Perpendicular	Top Down	G top	G	2	1/8	Longitudinal	NWP	D	
48	A503	833	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	
48	A503	828B	Yes	No	No	Binder	Perpendicular	Top Down	G top	F bottom	5	1/8	Longitudinal	NWP	D	EDGE
48	A503	829B	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A504	834	NCR	No	No	Binder	Perpendicular	Top Down	I top	I bottom	2	1/8	Longitudinal	NWP	E, D	EDGE
48	A504	835	NCR	No	No	Binder	Perpendicular	Top Down	I top	I	0.25	1/8	Long-Replicate	NWP	E, D	EDGE
48	A505	857	NCR	No	No	Binder	Perpendicular	Bottom Up	D mid	I top	6	2/8	Longitudinal	NWP	D	EDGE
48	A505	858	NCR	No	No	Binder	Perpendicular	Bottom Up	D mid	I top	6	2/8	Long-Replicate	NWP	D	EDGE
48	A506	853	NCR	No	No	Binder	Perpendicular	Top Down	I top	I	1	1/8	Longitudinal	NWP	D	EDGE
48	A506	854	NCR	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A507	843	NCR	No	No	Binder	Perpendicular	Top Down	I top	I	0.25	1/8	Longitudinal	NWP	D	EDGE
48	A507	844	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A508	819	Yes	No	No	Binder	Perpendicular	Top Down	G top	F top	3	1/8	Longitudinal	NWP	D	EDGE
48	A508	820	Yes	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Replicate	NWP	D	EDGE
48	A508	823	NCR	No	No	Binder	Perpendicular	Top Down	G top	F bottom	5	1/8	Longitudinal	NWP	D	
48	A508	824	NCR	No	No	Binder	Perpendicular	Top Down	G top	G	0.25	1/8	Long-Replicate	NWP	D	
48	A509	811	NCR	N/A	No	Binder	Perpendicular	Bottom Up	D mid	G top	9	1/2	Longitudinal	NWP	D	EDGE
48	A509	812	Yes	No	No	Binder	Perpendicular	Bottom Up	F bottom	G top	4.3	1/8	Long-Replicate	NWP	D	EDGE
48	A502	801	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Non reflected	NWP	E, D	
48	A503	827	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Long-Non reflected	NWP		
48	A504	836	NCR	No	No	Binder	Perpendicular	Bottom Up	D mid	D top	2.5	1/2	Long-Non reflected	NWP	E, D	

Summary:

Crack Mechanis	Total	RAP		VIRGIN	
		Thin	Thick	Thin	Thick
Bottom up	5		2	2	1
Top Down	12	4	4	1	3

State Code	Section	Core ID	Recovered	Irregularity	Cracked full depth	Cracked through	Crack Direction	Crack Mechanism	Layer of crack origin	Layer crack stopped	Crack depth	Crack width	Distress Type	WP / NWP	Layers Deteriorated	Pavement Edge
48	A502	802	NCR	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	G, E, D	
48	A502	803	Yes	Stripping	No	Binder	Perpendicular	Top Down	G top	E bottom	3	1/8	Fatigue	WP	E, D	
48	A503	825	Yes	No	No	Binder	Perpendicular	Bottom Up	D mid	G top	7	1/2	Fatigue	WP	E, D	
48	A503	826	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	E	
48	A507	841	NCR	No	No	Binder	Perpendicular	Top Down	I top	I bottom	1.5	1/8	Fatigue	WP	D	
48	A507	842	NCR	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	D	
48	A508	821	Yes	No	No	Binder	Perpendicular	Top Down	G top	F mid	4.5	1/8	Fatigue	WP	D	
48	A508	822	Yes	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	D	
48	A509	813	Yes	Stripping	No	Binder	Perpendicular	Top Down	G top	F bottom	4	1/8	Fatigue	WP	D	
48	A509	814	Yes	Stripping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fatig-Replicate	WP	D	

Summary:

Crack Mechanis	Total	RAP		VIRGIN	
		Thin	Thick	Thin	Thick
Bottom up	1		1		
Top Down	5	2	1		1

APPENDIX B

TXDOT REPORT

LESSONS LEARNED FROM RAP SECTIONS WITH 17 YEARS OF SERVICE

SUMMARY

Rehabilitation of our aging highway system is one of the primary concerns for highway agencies. To improve the ride, protect the pavement structure, and extend pavement life, the hot mix asphalt overlay is a common rehabilitation practice used on deteriorated pavements. It is well known that using RAP will decrease the cost of HMA, reduce waste, and conserve natural resources [Chesner et al. 1998]. With the recent budget shortfall and increase in the price of liquid asphalt (200%-300% in recent years), the recycling of millions of tons of pavement asphalt is a critical task for the Texas Department of Transportation (TxDOT). However, reflective cracking from the preexisting cracks is a major and persistent problem in asphalt overlays for HMA with RAP.

The SPS-5 test sections on US175 were constructed more than 17 years ago to address the effects of RAP (referred to 35% recycled materials in this study), milling, and overlay thickness. Field performance data and analyses results from SPS-5 sections provide opportunities to quantify the effects of these most critical parameters. Conclusions and observations are given as follows:

1. HMA test sections produced with and without RAP have performed satisfactorily. It is believed that the following factors contributed to the excellent crack resistance of the mixtures placed: (1) high asphalt content, (2) acceptable in-place density, and (3) high quality aggregates. The aggregates utilized in the 8 SPS-5 sections were from an igneous source having a low water absorption. In general, according to Hamburg and Overlay test results, mixtures produced with this type of aggregate are less prone to cracking and rutting.
2. The field performance data demonstrate that the sections without RAP outperform the sections with RAP, although both types of materials demonstrated satisfactory performance. The overlay test results correlate well with the field performance data, as cores from the virgin AC sections have a significantly higher number of cycles to failure than those from the RAP sections.
3. Thicker virgin overlay sections perform better, in terms of IRI and resisting reflective cracking, than the thinner sections. With the 40% of reflected cracking rate criterion, the life for virgin AC with a 5-inch overlay is 65% longer than that for 2-inch overlay. However, for the RAP AC, the 5-inch sections only have 14% longer life than the 2 inch sections.
4. Based on the analyses on resisting reflective cracking, it was found that one inch of RAP AC overlay is equivalent to 0.26 inch of virgin AC overlay based on the finding from this study.
5. The field distress surveys and data analysis suggest that there is no significant difference in performance between the milled and non-milled sections based on the fixed milling depth that was used in this study.

6. Although not all specimens from the SPS-5 sections passed the Hamburg test, the maximum rutting from those 8 sections is 0.5 inches after 17 years of service. It is believed that the solid foundation support helped to minimize the rutting.
7. The recovered asphalt binder from the HMA produced without RAP has standard penetration and DSR results which indicate the binder has not excessively aged. The high density of the mixes in the SPS-5 section may have prevented excessive oxidation of the binder.
8. The results from the SPS-5 test sections reveal that high quality mixes were able to bridge over a cracked surface.
9. The overlay tester is a practical test which can be performed for informational purposes to potentially evaluate the cracking susceptibility of HMA. Test results from the overlay tester have correlated well with the field performance data from this evaluation. However, it is also important to ensure that the mixture is resistant to rutting and moisture damage by meeting the Hamburg requirements that is required in all TxDOT 2004 HMA Standard Specifications.

INTRODUCTION

With the recent United States budget shortfall and increase in the price of liquid asphalt (200%-300% in recent years) the recycling of millions of tons of pavement asphalt is a critical task for the Texas Department of Transportation (TxDOT). TxDOT currently owns an estimated 1.5 million tons of Reclaimed Asphalt Pavement (RAP) [Rand, 2008]. Approximately 770,000 tons of RAP were donated to counties in 2006. It is well known that using RAP will decrease the cost of HMA, reduce waste, and conserve natural resources [Chesner et al. 1998]. Salvage value of RAP is estimated at $35 to $50 per ton, based on the August 2008 cost for asphalt binder. In 2005, McDaniel and Nantung (2005) reported that the Indiana DOT's savings in materials were nearly $330,000 per year, by adding only 5% RAP to more than 5 million tons of base and intermediate mixes. When more RAP is used in roads, it will stretch DOT budgets even further, so many DOTs are encouraging increased use of RAP. Many research projects have been funded to study increased amounts of RAP for routine use. Hampton [2006] reported that increased use of RAP could reward the contractors with lower costs and higher profits. Highway contractors are also looking forward to increasing RAP content due to the rise in paving costs.

Due to the benefits in costs reduction and environmental protection, there is a great tendency to use RAP. However, the most frequently observed distress in an overlay involving RAP is reflective cracking. Thus, the performance of RAP, and overlay thickness are important factors for pavement engineers to consider when making decisions on rehabilitation and maintenance activities.

Reflective cracking is a major and persistent problem that occurs on an overlay, above existing cracks in the underlying pavement [Makowski et al 2005]. Reflective cracking can lead to premature deterioration of the pavement structure by infiltration of moisture, as it will cause stripping in the HMA and weaken the supporting layers. Reflective cracking will be one of the main concerns when RAP is applied to deteriorated pavements that already have a

fair amount of cracks. The most frequently observed distress on an asphalt overlay involving RAP is reflective cracking.

Chen and Daleiden [2005] reported that after more than 10 years of service, the SPS-5 sections on US175 with 35% of RAP have performed exceptionally well. Cracks were observed on the shoulders, but stop at the travel lanes where the overlay treatments were applied, on both RAP and virgin sections. Fig. 1 shows photos taken in 2004, after 13 years of service, where the cracks stop on the travel lanes of sites A505 (virgin) and A509 (RAP). TxDOT would normally expect a rehabilitation project on flexible pavement to last for 8 years. After more than 10 years of service, the RAP sections performed as well as the virgin sections.

Surface preparation was also a factor in SPS-5 experimental design. Surface preparation herein refers to a 2-inch (50mm) milling of existing pavement section before overlay. It was observed that there was not much difference in performance between the milled and non-milled sections. However, there was less distress on the 5-inch (125mm) thick sections than the 2-inch (50mm) thick sections [Chen and Daleiden 2005].

Tighe et al [2003] documented that the economic benefits of reduced cracking include: (1) increased life of the original pavement or overlay, (2) lower maintenance costs, (3) lower vehicle operating costs due to higher ride quality, and (4) lower user delay costs because of later preventive and rehabilitative maintenance interventions.

Seventeen years have passed since the rehabilitation done in 1991. Different degrees of distress have appeared on sections that had none before, including the 5-inch (125mm) thick sections. The performance information provides a valuable opportunity to determine the effectiveness of various treatments. A comprehensive evaluation was performed to determine what factors contributed to the excellent performance of the SPS-5 sections under study. With a better understanding of the most critical parameters, the success of these SPS-5 sections can be duplicated in future projects. In addition, efforts were made to verify if mechanical tests, Overlay and Hamburg, correspond to the field performance of the SPS-5 sections.

SITE DESCRIPTION

The purpose of the SPS-5 experiment on US175 is to compare the effectiveness of rehabilitation treatments for thin and thick overlays, constructed with virgin material and material incorporating RAP, on milled and non-milled surfaces. Based on 2007 TxDOT traffic data, the 20-year design traffic (2007- 2027) for US175 was 12.7 million 80kN Equivalent Single Axle Loads (ESALs) with an Annual Average Daily Traffic (AADT) of 33,990 vehicles. The Asphalt Concrete (AC) surface thickness varies from section to section, as shown in Figs. 2 and 3. Under the surface layer, there is 12 inches (300mm) of lime-stabilized base and 18 inches (455mm) of lime-stabilized subgrade. Lime stabilization of these layers provides a pavement foundation which is initially sound, but may be prone to cracking.

The eight test sections representing different combinations of these three design factors were placed adjacent to each other for comparison, as shown in Table 1 for details. For easy comparison, the last column of Table 1 shows the abbreviation utilized throughout the

document. For example, 2RM, 5RNM, 2VM, and 5VNM denote 2-inch RAP AC with milling, 5-inch RAP AC with no milling, 2-inch virgin AC with milling, and 5-inch virgin AC with no milling, respectively. These eight SPS-5 sections were built in 1991. After 17 years of trafficking, the main distress on US 175 is cracking, with maximum rutting of approximately 0.5 inch in only one of the 8 sections.

RAP was used in four SPS-5 sections with 35% recycled material added to the virgin mix. The 65% virgin AC had an AC-5 grade binder. AC-10, with a 3% latex modifier, was used in four virgin SPS-5 sections. Mix designs were performed for both RAP and virgin sections. Type C mixtures were used for the top 2-inch AC (RAP and no-RAP sections). Similarly, Type B mixtures were used for the lower layer AC (or binder course). Anti-stripping agents Perma Tac Plus and Adhere HP Plus were added to the Type C and Type B mixes, respectively. Note that a softer grade asphalt (AC-5) was used in the RAP sections. The Type C mix design for RAP sections consisted of 4.5% asphalt with Traprock and Granite screenings. The Type C mix design for virgin section consisted of 5.2% asphalt with Traprock and Granite screenings. Both Traprock and Granite screenings are among the hardest rocks with least water absorption. Tables 2 and 3 present the gradation of the mixes, and absorption test results. More comments on absorption test results will be presented later in the paper.

The milled sections called for a 2-inch milling of the existing AC surface, then application of a 2-inch AC mixture prior to the 2-inch or 5-inch overlay, as shown in Fig. 3. This means the 2-inch sections with milling actually have 4 inches of the AC overlay, and 5-inch sections with milling have 7 inches of AC overlay.

LABORATORY AND FIELD PERFORMANCE ANALYSES

Roughness

Roughness has been utilized to indicate the ride comfort and assess the pavement performance. The roughness of the test section is quantified using the International Roughness Index (IRI). To evaluate the change in roughness performance, the 'before' rehabilitation data collected in 1991, and the 'after' rehabilitation data collected in 1992, 2000 and 2007 are compared in Fig. 4. Only the 2007 IRI data was available at the time of this study, so, those are the latest data set used. Even 16 years after rehabilitation, the IRI values for several sections have not exceeded the value before the rehabilitation in 1991. Efforts were made to compute the roughness change between 1991 and 2007, as shown in Table 4. Positive and negative values in Table 4 mean IRI increased or decreased relative to the IRI before rehabilitation in 1991. Table 4 indicates that section A509 (2-inch RAP with milling) had the most improvement in ride quality (a 33.8% reduction after 16 yrs of service). In contrast, section A506, a 2-inch virgin AC section with milling has the poorest performance in terms of IRI, an increase of 15.23% . Excluding section A505 (2-inch virgin AC without milling), the sections' IRI values are in the range of 76 to 88.7 inch/mile (1.2 to 1.4 m/km). IRI values of 76 to 88.7 inch/mile (1.2 to 1.4 m/km) can be classified as a fairly good ride. Generally, the roughness of the sections increased with time. However, the increase in roughness is less for pavements with a thicker overlay, as the three lowest IRIs all had the 5-inch overlay. It was concluded that in terms of the IRI or roughness, the RAP and virgin sections performed exceptionally and equally well in combating the increase in

roughness over the years. However, there are significant differences in terms of reflective cracking performance between the virgin and RAP sections. Subsequent sections present comparisons of reflective cracking from field measurements and extensive lab test results to characterize virgin and RAP materials.

Material Tests

Three cores from a virgin AC section (A504) and three cores from recycled sections (A503) were tested by the Flexible Pavements Branch of TxDOT. Only the average results are presented in Tables 5 and 6 for A503 and A504, respectively. The test results in Tables 5 and 6 include the 9 inches of the original AC.

Even after 17 years of service, the penetration results for the recovered binder of the top 5 inches of virgin material were found to be exceeding 45. Based on penetration and DSR results, the binder for the top 5 inches of no-RAP material performed as a PG 64-XX binder. The high penetration numbers and soft binder classification indicate that the virgin material does not appear to be over-aged. The determined AC content of both the virgin AC and RAP were all within 0.3% of the original design targets. The target AC content for Type C in this study was 5.2%, which is about 0.6% higher than a typical Type C of 4.6%. The high AC content and high densities (96% to 99%) are believed to have helped retard the oxidation and enhance the crack resistance.

After 17 years of service, the penetration results are found to be 18 and 27 for the top 2 inches (Ty C) and lower AC (Ty B) of the RAP section (A508), respectively. The lower penetration numbers are expected for RAP, as it is normally stiffer. Chen and Daleiden (2005) reported that after 10 years of service, the RAP material on US175 was found to have penetration numbers exceeding 35. This suggests that the RAP sections are undergoing aging to some extent. The extracted binders from the RAP sections performed as a PG 70-XX binder, which is one grade higher than the PG64 virgin section. It is well known that RAP is able to bump one PG grade.

Based on field observations, water absorption is a good indicator of aggregate quality or hardness. Zhou et al. [2007] reported that the aggregate quality plays a critical role in combating reflective cracks. They found that the water absorption of aggregates in Texas ranges from 0.1 to 2.5%. Based on the lab test results and field observation, it concluded that when the water absorption of aggregate is less than 1.0%, the aggregate would yield excellent overlay test results. Table 3 presents the water absorption of the aggregates (Granite, Traprock, and Screening) utilized in the SPS5 sections. In view of these results, water absorptions of Granite, Traprock, and Screening are all less than 0.75%. The low water absorption is believed to contributed to the excellent performance on the underlying eight SPS-5 sections. In general, aggregates with low water absorption (e.g. less than 1%) perform well since less asphalt is absorbed thus producing a thicker film of asphalt around the aggregates. This generally produces a mixture less prone to excessive aging and cracking. Aggregate with low water absorption are generally the higher quality aggregates in Texas. The two are generally linked together.

Overlay Test

To be able to evaluate the mix's ability to resist reflective cracking for an extended time, a simple performance test was used. Based on extensive laboratory and field performance monitoring, Zhou and Scullion [2005] and Zhou et al. [2007] found that the results from the Overlay Test (OT) correlated very well with cracking found in the field. An HMA with 700 or more cycles to failure at 25º C (77º F) is classified as an excellent material to resist reflective cracking.

The test specimens for the OT were 6 inch (150mm) long by 3 inch (75mm) by 3 inch (75mm), cut from the 6 inch (150mm) diameter field cores collected in October 2008. Cores from the 3 virgin AC sections (504, 505, and 507) were evaluated with the OT, and all exceeded 2000 cycles. The OT results from the 3 RAP sections (502, 503, and 508) lasted 414, 8 and 6 cycles, respectively. It was surprising that even after 17 years, the virgin AC section still had excellent fatigue resistance as the lives exceeded 2000 cycles. This indicates that an asphalt overlay can be very effective in resisting reflective cracking, when it is designed and constructed properly. Although the RAP sections had low OT results (except section 502) they have performed satisfactorily for over 17 years. The OT test results match the field observations, as fewer cracks are observed on the virgin AC sections. Thus, it is believed that the OT can be applied with success to characterize an asphalt mix's ability to resist reflective cracking.

With extensive overlay tests performed by TTI [Zhou et al. 2007], it was found that the mixes produced with aggregate having a water absorption of less than 1% normally yielded higher OT results. Thus, the combination of the OT and mixtures with high quality aggregate and sufficient asphalt can create cracking resistance mixtures.

Transverse Cracks

Fig. 5 shows comparisons of the transverse cracks among the 8 sections after 16 years of service. Only the '2007' (after 16 years of service) data are available at the time of this study and thus they were used in the analyses. The ranking of the sections, with most to least transverse cracks, are 2RM, 2RNM, 5RNM, 2VNM, 5RM, 2VM, 5VM, and 5VNM.

The following trends were observed:

(1) 5-inch thick sections perform better than 2-inch thick sections,

(2) Virgin AC sections perform better than the RAP sections, and

(3) Milled sections perform slightly better than the non-milled sections.

It should be noted that the milled sections had 2 extra inches of new (vs. existing) AC. Thus, the 2-inch milled sections had 4 inches of overlaid AC, and the 5-inch milled sections had 7 inches of overlaid AC. Thus, it is one of the main reasons the milled sections did perform better than the non-milled sections. However, it by no means indicates that 2-in. milling of existing pavement before overlay contributed to better pavement performance if the contribution of the 2-in. replaced AC is separated from the combined effect.

It is well known that overlay performance also depends on a pavement's preexisting condition. The percent change between before rehab and after 16 years of service were computed and are presented in Table 7. Positive and negative values in Table 5 mean transverse cracks increased or decreased relative to the number of transverse cracks present

before the 1991 rehab. The transverse crack development in Fig. 5 and Table 7 (for A503, A505, A507, and A508) can be used with confidence because it was quantified and considered before and after the rehab. However, the majority of distress in sections A502, A504, A506, and A509 was in the form of block and alligator cracking. Although there was severe distress in those 4 sections, not all of the transverse cracks were counted, because they were obscured by the block and alligator cracking. That is the main reason for the 1100% increase in transverse cracks for section A502. Thus, there is an inherent weakness in the method of quantifying the distress based on transverse cracks alone.

In view of Table 7, it was observed that the lengths of the transverse cracks in 2007 are approximately 60% less than those in 1991, except in sections A502 and A509. This was because the two sections had significant block and alligator cracks in 1991, and those cracks have reflected through in the form of transverse cracks. Although there was a significant amount of block cracking in A504 and A506, there are fewer transverse cracks in 2007 than in 1991. It is believed that the virgin AC overlays in those two sections were able to bridge over the cracks and minimize reflective cracks. This demonstrates the ability of virgin mix to resist reflective cracks. It warrants further investigation of virgin mix to understand the parameters that contribute to superior performance.

Reflective Cracks

To reasonably quantify reflective cracks, crack development in terms of percentage of cracked area was established in this study. One of the benefits of adopting percentage in this approach is its ability to incorporate the preexisting distress conditions. The percentage of cracked area is defined as the number of grid squares with cracks or distress, divided by the total number of grid squares with cracks before overlay construction. The severity of cracking is not considered; as long as there is a crack in a square, that square is considered cracked.

Different types of cracks (transverse, longitudinal, alligator, and block cracking) that occurred before the overlay rehabilitation are considered. Likewise, different types of cracks that occurred after the rehabilitation are considered as well. However, only the cracks that occur on the same part of the grid will be counted as reflected cracks. It is authors' opinions that reflective cracks approach should be used to evaluate the effectiveness of the rehab treatments as it has the ability to take the pre-existing condition into account.

The percentage of cracked area depends heavily on the grid size. Chen [1998] reported that the larger the grid size, the higher the calculated percentage of cracked area. Considering the crack maps available from LTPP, a grid size of 1m by 1m was selected. Fig. 7 illustrates the typical crack maps in 1991 (pre-rehab) and 2003 (after) rehab. Fig. 8 shows the crack maps superimposed on the 1m by 1m grid. Fig. 8 also illustrates the reflective crack development. A clear trend was observed that three of the four virgin AC sections (A504, A506, and A507) have the lowest number of reflective cracks. The results in Fig. 9 clearly demonstrate that the virgin AC sections outperform the RAP sections. The main reasons for the higher reflective cracks in section A505 (virgin AC) are as follows:

(1) less cracked areas in 1991, and thus few reflective cracks that would lead to a higher percentage of reflective cracked areas

(2) The 2-inch non-milled section has a thinner overlay. It will be explained in the next section that the overlay thickness plays an important role in the development of the reflective cracking.

Although one could compare the field performance in a general manner, due to the combined contribution the performance, the individual effects of milling, material type (virgin or RAP), and thickness would be difficult to quantify. Thus, there is a need to develop an E-M model to systematically account for the three critical factors.

Quantifying the Effect of Milling, Material, and Overlay Thickness

To quantify the effects of milling, material type (virgin or RAP), and overlay thickness, an empirical-mechanistic (E-M) model is developed in this study. The end results from the analyses provide information on the effectiveness of milling, material type, and overlay thickness that allows engineers to make better decisions concerning overlays. First, a mechanistic model was developed by incorporating the controlling parameters (e.g. Milling, Virgin AC, and Overlay Thickness) into a basic/prototype crack propagation model. Second, a non-regression analysis was conducted to estimate the model parameters that will indicate the effect of different factors' effect on field pavement performance.

The sigmoid function in Equation 1 is the basic crack propagation model. Equation 1 implies that with increase of time or load repetitions, the extent of cracks increases exponentially until it reaches a stable asymptote. The exponential variables (b_2 and b_3) in the denominator affect the steepness of the curve. Larger values indicate a slower rate of reflective crack development.

$$f(x) = \frac{b_1}{1 + e^{b_2 + b_3 x}} \quad [1]$$

Where,

x: variable describing pavement information, and;

$b_1 \sim b_3$: parameters that can be expanded to include controlling parameters (milling, virgin/RAP, and overlay thickness).

By incorporating the relevant variables into the above basic model based on engineering judgment, the final model specification is presented as follows.

$$y_{i,t} = \frac{\beta_1}{1 + e^{\beta_2 + (\beta_3 + \beta_4 ML_i + \exp(\beta_5 RP_i)(\beta_6 TH_{i_i}))T_{i,t}}} \quad [2]$$

Where,

$y_{i,t}$: Reflective crack in section i (each 500 ft or 152.4 m long) at time point t;

ML: Indication of construction preparation, ML = 1 for mill, and 0 for no mill;

RP: Indication of overlay material, *RP* =1 for RAP, RP = 0 for virgin AC;
TH: Overlay thickness (in or mm);
T: Time after overlay construction (years);
$\beta_1 \sim \beta_6$: Material Parameters

By employing the least-square regression technique with nonlinear model estimation, the parameters ($\beta_1 \sim \beta_6$) were computed, as given in Eq. 3. The R^2 value of 0.93 suggests that the model is well fitted to the field observations. Fig. 10 summarizes the comparisons between the observation and model predictions using Eq. 3.

$$y = \frac{71.3}{1 + e^{5.492 + (-0.660 - 0.012\,ML + \exp(-1.349\,RP)(0.069\,TH))T}}\% \qquad [3]$$

It was interesting to find that the parameter corresponding to milling $\hat{\beta}_4$ is very small and statistically insignificant, implying that the 2-inch milling before overlay does not contribute to better overlay performance in terms of reflective cracks. It is believed that if the existing cracks are completely milled, that would be helpful in reducing cracks in the overlay. However, the field coring survey indicated that the underlying cracks were not totally removed, as evident in Fig. 6. Notice that Fig. 9 shows a slightly better performance for the milled sections than the non-milled sections; this was because the 2-inch milled layer was replaced with 2 inches of fresh hot mix. In the underlying model in this study, the 2 inches of replaced hot mix was taken into account as part of the overlay thickness, and thus it compensated the "ineffectiveness" of the milling.

Efforts were made to quantify the effects of the overlay thickness. The statistical significance and positive sign of $\hat{\beta}_6$ indicate that a thin overlay is more prone to reflective cracking than a thick overlay. For example, at the end of eight years (customarily expected minimum overlay service life), the reflective cracking rate for virgin AC with a 2-inch overlay is 4.3 times higher than that for 5-inch overlay. Similarly, for RAP AC with a 2-inch overlay is 1.3 times higher than that 5-inch overlay.

NCHRP 1-37A research report "Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures" (ARA Inc. 2004) suggested a reflected cracking rate of 40 % as the design criterion. It means a pavement is failed when it reaches 40 % of reflected cracking rate. Under the 40 % of reflected cracking rate criterion, the life for virgin AC with a 5-inch overlay is 1.65 times higher than that for 2-inch overlay. Similarly, the life for RAP AC with a 5-inch overlay is 1.14 times higher than that for 2-inch overlay. It means thicker virgin AC is very effective to minimize the reflective cracking because it has 65% longer life for 5 inch sections than the 2 inch sections. However, for the RAP AC, the 5-inch sections only has 14% longer life than the 2 inch sections

The statistical significance and negative sign of $\hat{\beta}_5$ suggests that an overlay containing RAP (with 35% recycled mixture) exhibits more overall reflective cracking than one with only virgin asphalt. Fig. 11 illustrates in detail the comparisons of Reflective Cracking Rate between the RAP and virgin section. The comparisons of field observation (referred as

"obs") and model prediction (referred as "pre") using Eq. 3 are superimposed on Fig. 11. Under all circumstances, the virgin AC sections outperform RAP sections. The relative effectiveness of AC with 35% RAP is about 26% that of virgin AC, in terms of capacity to resist transverse cracking. This stems from the fact that $\exp(\hat{\beta}_5 RP)$ has a value of 0.26 when $RP = 1$. It means one inch of RAP AC overlay is equivalent to 0.26 inch of virgin AC overlay. To better reflect the effect of both significant factors, materials and thickness on reflective cracking, a more comprehensive comparison is illustrated in Fig. 12.

Rutting

Although the Hamburg wheel track test results shown in Table 8 that most of the tested specimens did not meet the current TxDOT requirements for PG 76-XX binders (over 20,000 passes when reaching 0.5 inch or 12.5 mm rut depth), no significant rutting was found on these 8 sections. The maximum rutting after 17 years of service is 0.5 inches on section A507. That section has virgin AC and low Hamburg results according to the requirements for a PG 64 binder. It is believed that sound foundation support on the 8 sections is one of the main contributing factors that kept rut minimal.

DISCUSSION

Lime stabilization of the base and subgrade layers provides a pavement foundation which is sound, but can be prone to cracking. This is the case with US175, where the main distress is cracking. It was found that after more than 17 years of service, the RAP sections have been performing satisfactory. This indicates that RAP can be very effective when it is designed and constructed properly. In addition, by incorporating mechanistic and empirical approaches, the analysis results suggest that 1) milling of existing pavement does not reduce reflective cracking if existing cracking is not completely removed, 2) a thicker overlay does contribute to reflective crack resistance, and 3) on average, the pavement life for RAP sections are approximately 0.4 times as long as virgin AC sections based on the findings from this study. Within the first 8 years of service, there is no significant difference between RAP and virgin AC sections. The results from the SPS-5 test sections also suggest that a flexible mix will be able to bridge over the cracked surface. In addition, even after more than 17 years of service, the overlay tester results indicate that the AC overlay with virgin asphalt mix still possesses excellent resistance to reflective cracking.

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Table 1 Eight SPS-5 Test Sections on US175

Section ID	Overlay Thickness	AC Property	Milling	Referred in Figures as
A502	50mm	Recycled	no	2"RNM
A503	125mm	Recycled	no	5"RNM
A504	125mm	Virgin	50mm	5"VM
A505	50mm	Virgin	no	2"VNM
A506	50mm	Virgin	50mm	2"VM
A507	125mm	Virgin	no	5"VNM
A508	125mm	Recycled	50mm	5"RM
A509	50mm	Recycled	50mm	2"RM

Table 2 Gradations

Sieve Size	RAP-Ty B	RAP-Ty C	Virgin-Ty B	Virgin-Ty C
1"	0.0	0.0	0.0	0.0
1"-7/8"	0-5	0.0	0-5	0-5
7/8"-5/8"	8-16.9	0-5	8-14.1	16-25.9
5/8"-3/8"	11.9-21.9	21.8-31.8	11.5-21.5	
3/8"-#4	16.5-26.5	14-24	17.8-27.8	16.1-26.1
#4-#10	9.9-19.9	11-20.4	40043.0	11.7-21.7
#10	61.8-71.8	58.6-68.6	58.4-68.4	54.5-64.5
#10-#40	6.9-12.9	8.8-14.8	10.2-16.2	11.2-17.2
#40-#80	13-19	13.6-19.6	12.5-18.5	13.5-19.5
#80-#200	3-8.6	3-9	3-8.8	4.3-10.3
#200	1-4.7	1-5	1-5.1	1-5.5

Table 3 Absorption Test Results

Absorption	Virgin Ty B Mix	RAP Ty B Mix
Ty B Granite	0.40%	0.2%
Ty D Granite	0.60%	0.4%
Stone Screenings	0.7%	0.3%
Absorption	Virgin Ty C Mix	RAP Ty C Mix
Ty C Traprock	0.70%	0.40%
Ty D Traprock	0.70%	0.40%
Stone Screenings	0.70%	0.30%

Table 4 Comparisons of the IRI between Before Rehab and 16 yrs After Rehab

Section	Performance Change (Before vs. After)		
	IRI (m/km)		
	Before (1991)	After (2007)	Percent Change
A502	1.375	1.396	1.53%
A503	1.492	1.241	-16.82%
A504	1.38	1.472	6.67%
A505	1.545	1.746	13.01%
A506	1.182	1.362	15.23%
A507	1.463	1.262	-13.74%
A508	1.258	1.213	-3.58%
A509	1.945	1.287	-33.83%

Table 5 Lab Test Results for A503 from the Cores Taken in 2008 (After 17 yrs of Service)

A503	Layer Thickness (in)	~Depth (in)	Density (%)	AC (%)	Pen at 77F	DSR @ 64	DSR @ 70	DSR @ 76	Classification
RAP-Ty C	2.05	0-2	98.86	4.63	18	6.56	2.80	1.31	PG70
RAP-Ty B	2.96	2--5	95.20	3.83	27	4.77	2.09	0.97	PG70
Original AC	1.43	5-6.5	97.46	4.83	10	14.50	8.91	3.97	PG76
Original AC	7.46	6.5-14	98.15	5.23	24	3.25	1.46	0.67	PG64

Table 6 Lab Test Results for A504 from the Cores Taken in 2008 (After 17 yrs of Service)

A504	Layer Thickness (in)	~Depth (in)	Density (%)	AC (%)	Pen at 77F	DSR @ 64	DSR @ 70	DSR @ 76	Classification
Virgin-Ty C	2.06	0-2	99.03	5.30	64	1.33	0.66	0.36	PG64
Virgin-Ty B	2.45	2--5	97.17	4.53	49	1.60	0.80	0.43	PG64
Milled and Inlay	1.44	5-6.5	96.84	4.67	11	21.00	8.59	3.64	PG76
Original AC	8.38	6.5-15	97.47	4.83	23	3.34	1.45	0.72	PG64

Table 7 Comparisons of the Transverse Crack between Before Rehab and 16 yrs After Rehab

Section	Performance Change (Before vs. After)			
	Trans. Crack Length (m)		Percent Change	Comment
	Before (1991)	After (2007)		
A502	9.9	122.6	1138.38%	With majority of block cracks did not count as transverse cracks in 1991
A503	279.5	97.1	-65.26%	
A504	193.3	3.2	-98.34%	With majority of block cracks did not count as transverse cracks in 1991
A505	166.6	66.4	-60.14%	
A506	69.7	5.2	-92.54%	With majority of block cracks did not count as transverse cracks in 1991
A507	222.6	1.7	-99.24%	
A508	229.2	67.7	-70.46%	
A509	64.7	166.2	156.88%	With majority of block cracks did not count as transverse cracks in 1991

Table 8 Summary of Hamburg Wheel Track Test & Overlay Test Results

Material ID	Hamburg # Passes at Failure*	Overlay Test Number of Cycles to Failure
48A502-RAP Surface C	>20000	414
48A503-RAP Surface C	>20000	8
48A504-Virgin Surface C	14300	>12000
48A505-Virgin Surface C	>20000	>12000
48A507-Virgin Surface C	8728	>12000
48A507-Virgin Base B	7400	
48A508-RAP Surface C	9400	6
48A508-RAP Base B	2450	

*: A rut depth of 0.5 inch or 12.5mm indicates failure.

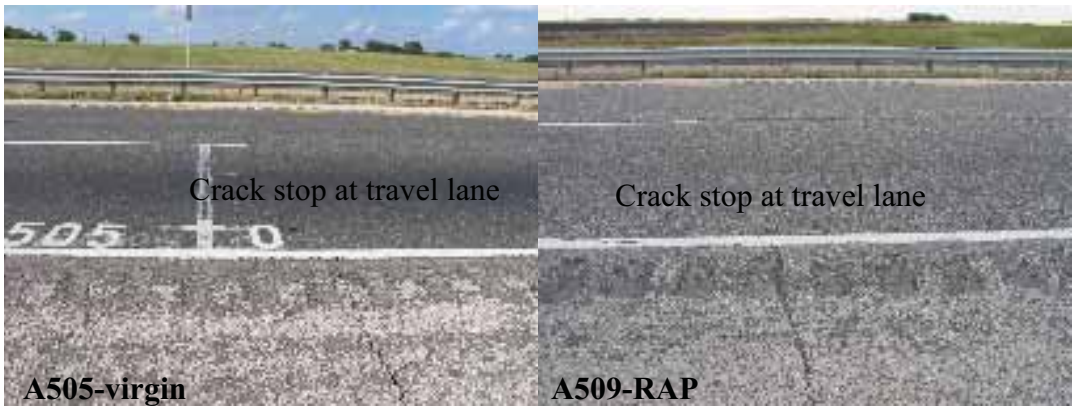
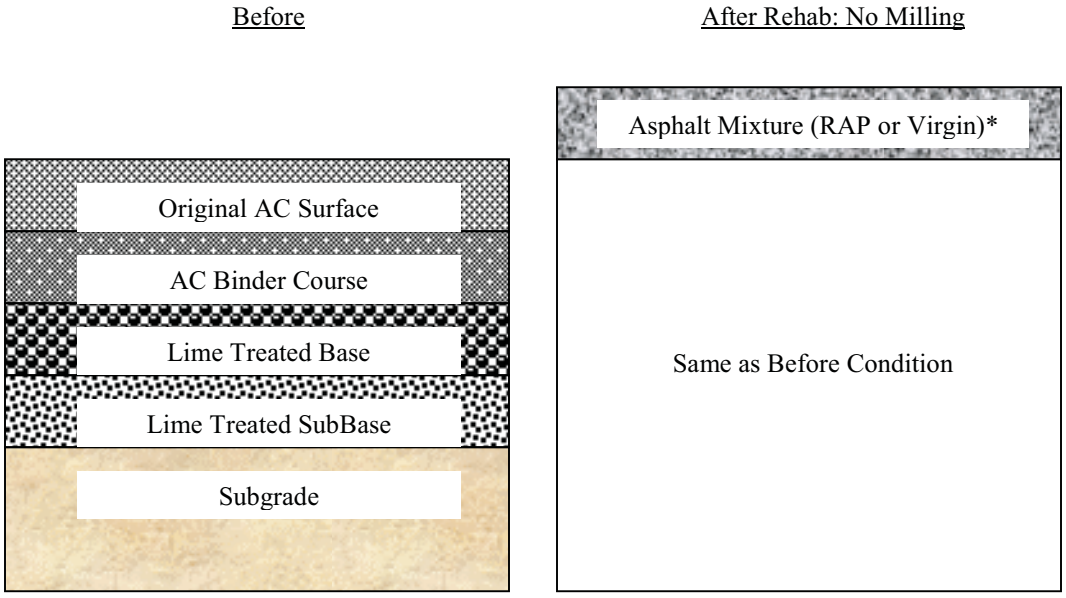
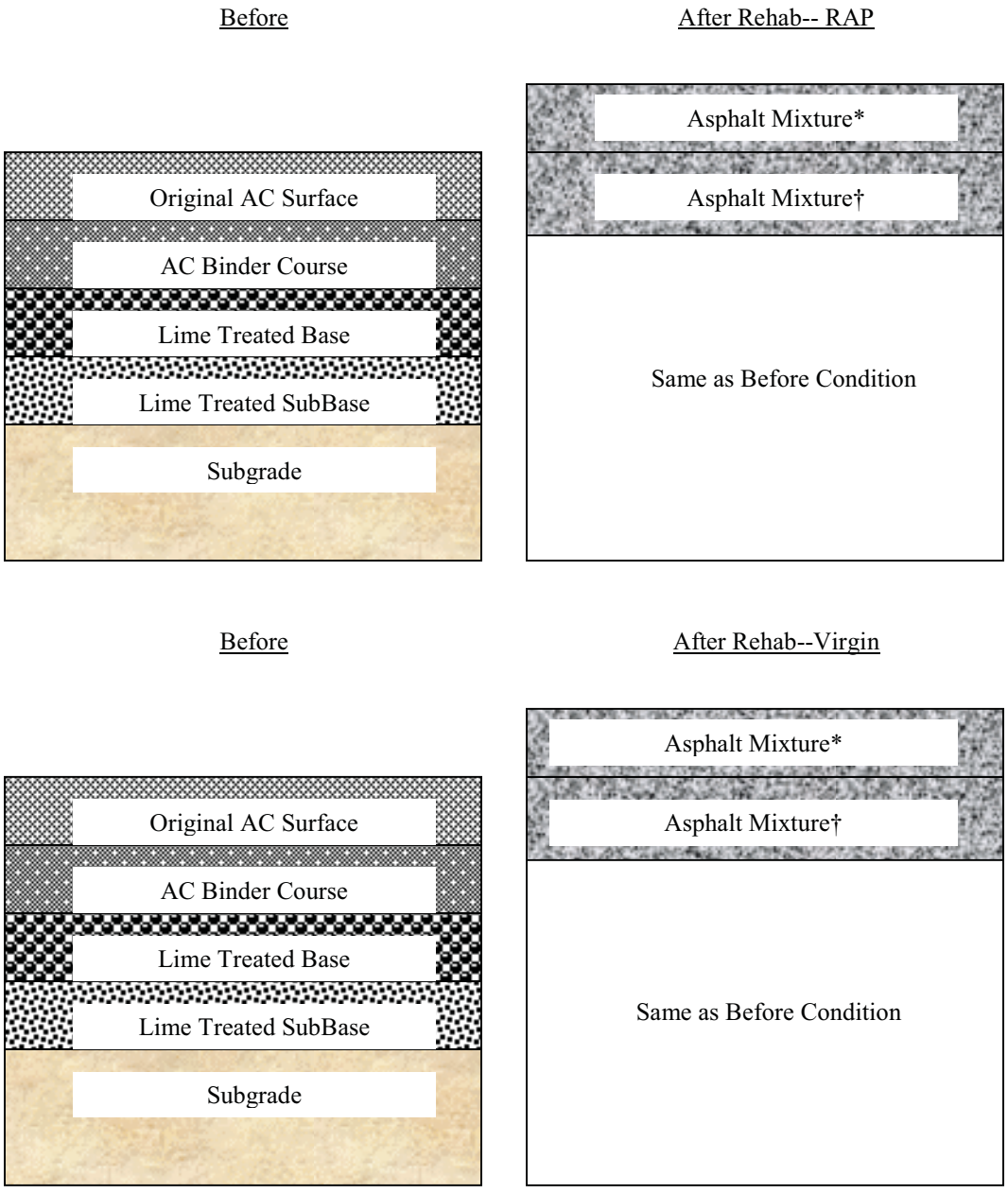


Fig. 1 Pictures Were Taken in 2004 after 13 Years of Service for Site A505 (virgin) and A509 (RAP)



*: 5.2% and 4.8% asphalt binder (AC10) +3% latex was used in the surface course and binder course (if adopted) respectively for the Virgin sections and 4.5% and 3.8% AC5 was used in the surface course and binder course (if adopted) respectively for the RAP sections

Fig. 2 Comparisons of the Before and After Typical Sections for No-Milling Sections



*: 5.2% and 4.8% asphalt binder (AC10) +3% latex was used in the surface course and binder course (if adopted) respectively for the Virgin sections and 4.5% and 3.8% AC5 was used in the surface course and binder course (if adopted) respectively for the RAP sections

†: Same material as the immediate above layer

Fig. 3 Comparisons of the Before and After Typical Sections for Milling Sections

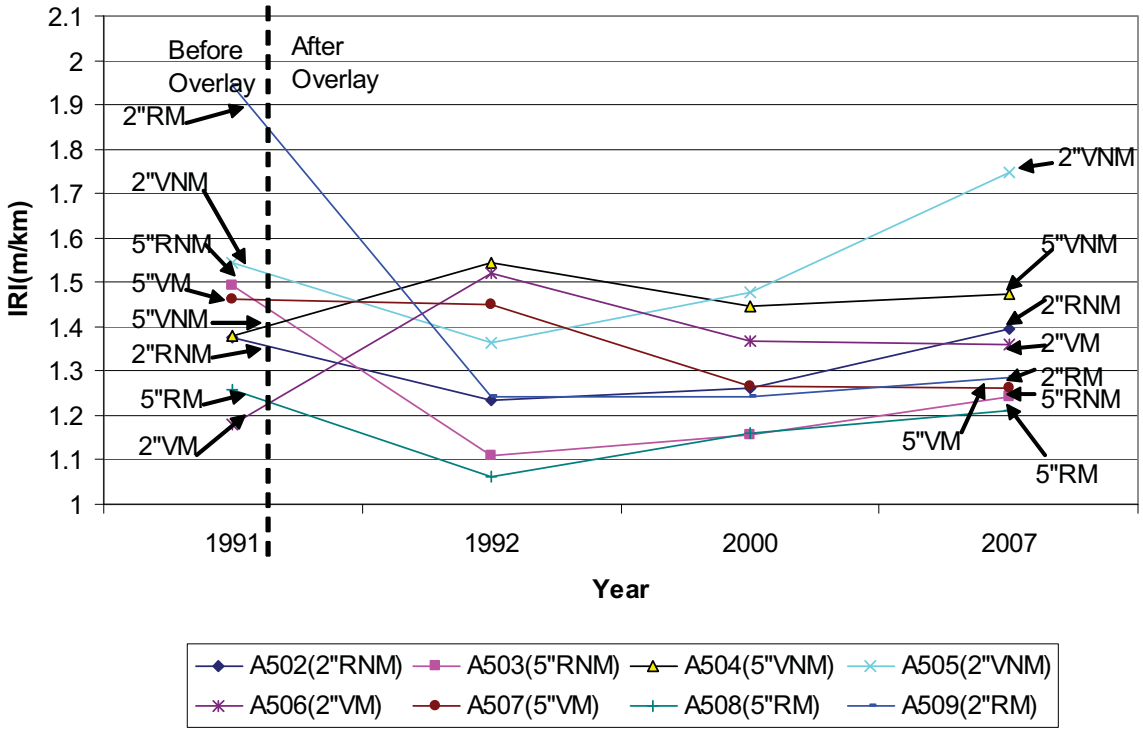


Fig. 4 Comparisons of the IRIs Among Different Treatments

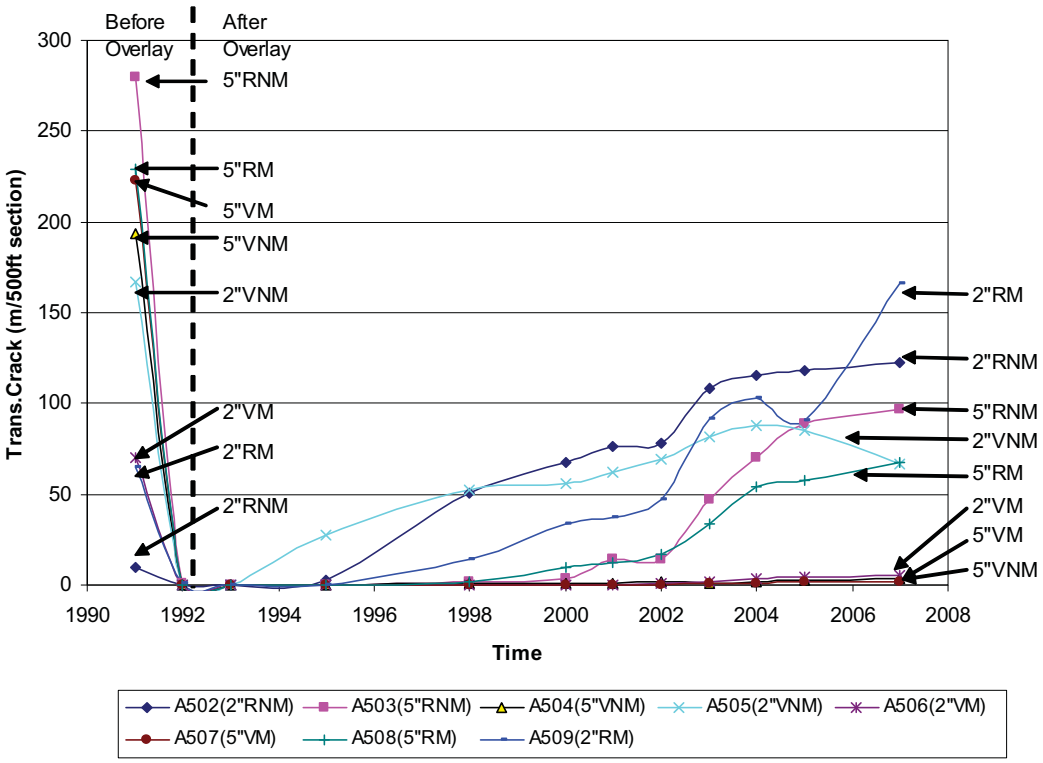
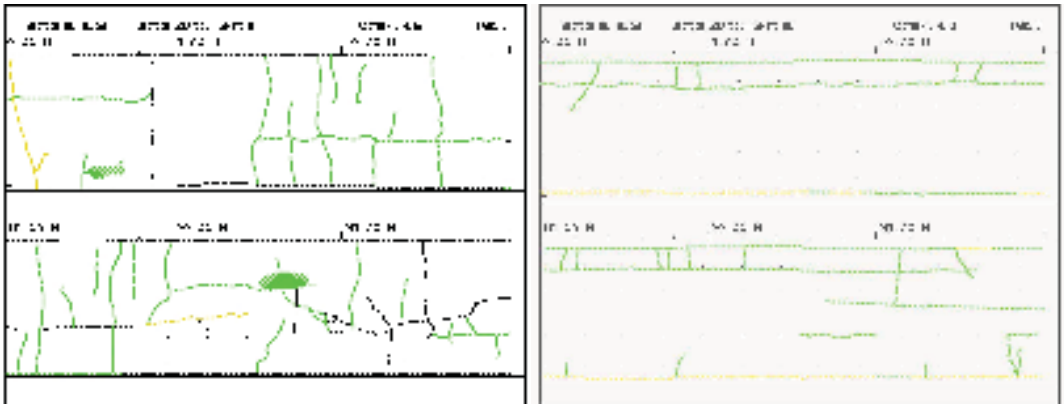
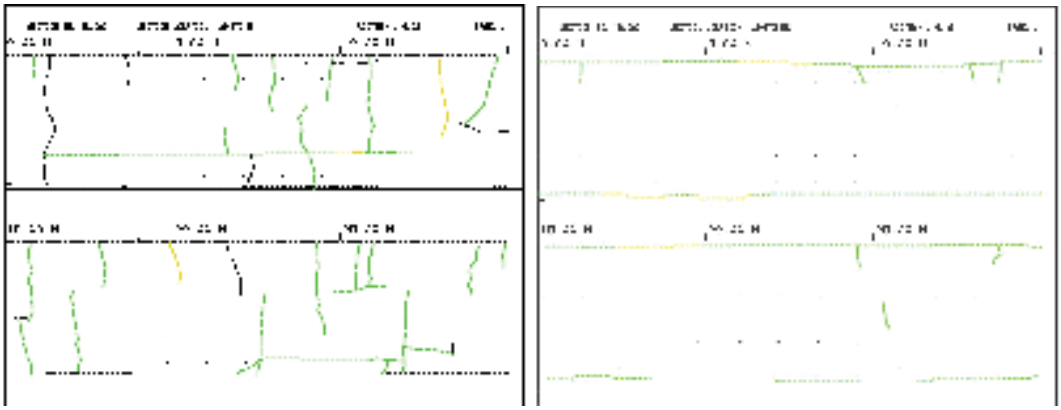


Fig. 5 Comparisons of the Transverse Cracks Among Different Treatments

Fig. 6 Core showing Reflective Transverse Crack (2008) from Site A509 after More than 17 Years of Service

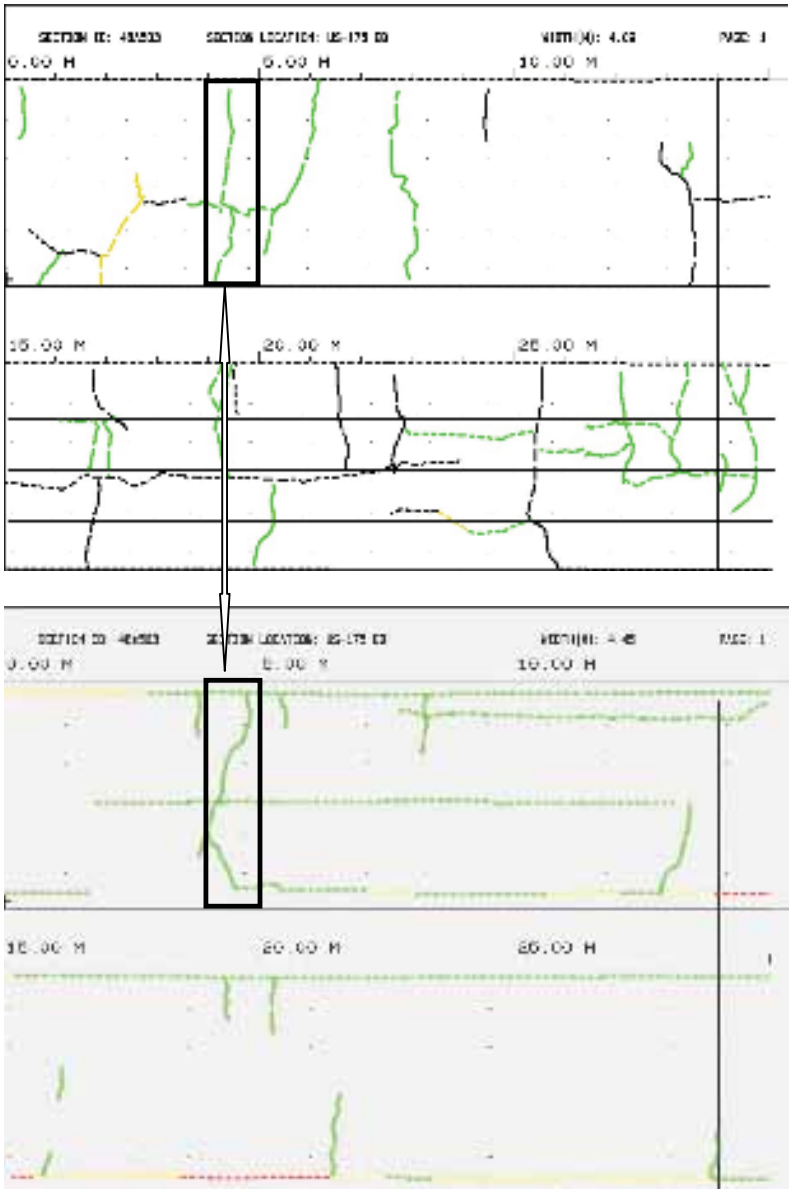


Crack Maps for Pre (1991) and After (2003) Rehab Condition for Site A508



Crack Maps for Pre (1991) and After (2003) Rehab Condition for Site A505

Fig. 7 Typical Crack Maps for Pre (1991) and After Rehab (2003)



503

Fig. 8 Typical Crack Maps with 1m by 1m Grid At Pre (1991) and After Rehab (2003) Conditions

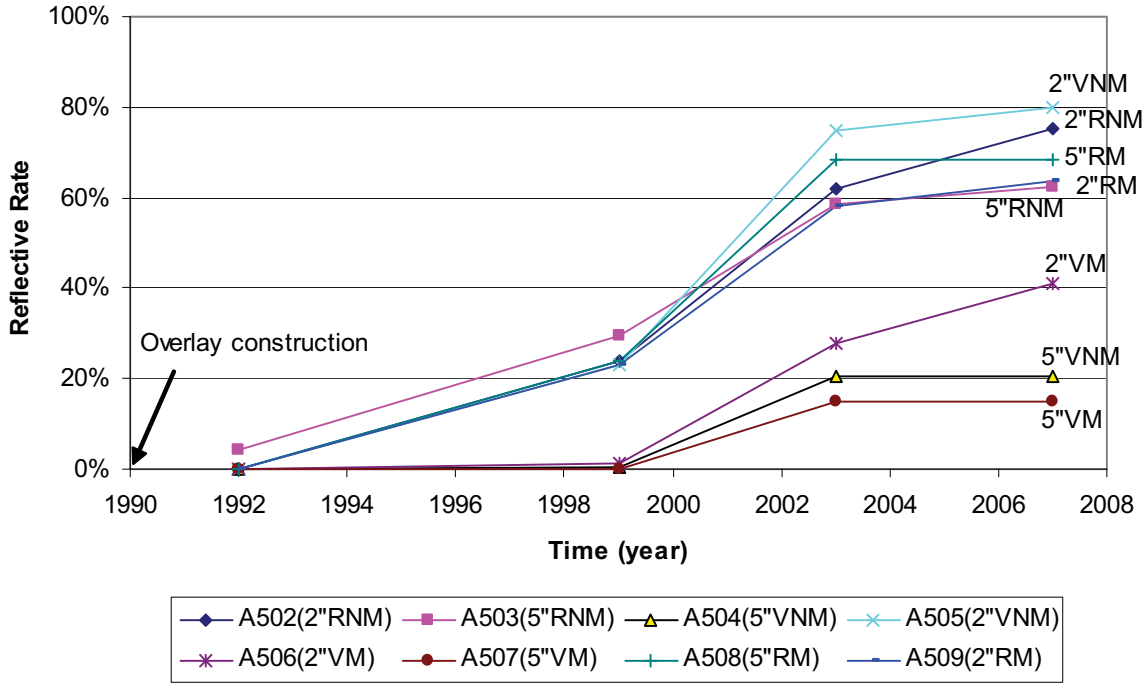


Fig. 9 Comparisons of the Reflective Cracking Rate

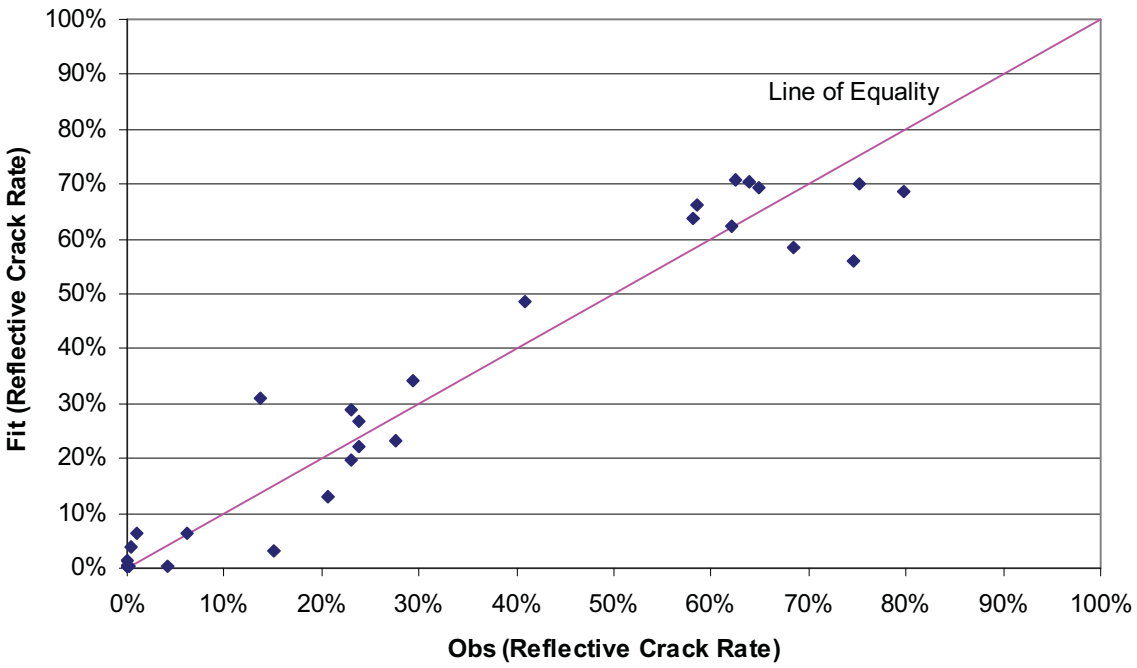


Fig. 10 Comparisons of the Field Observation and Model Prediction Using Eq. 3.

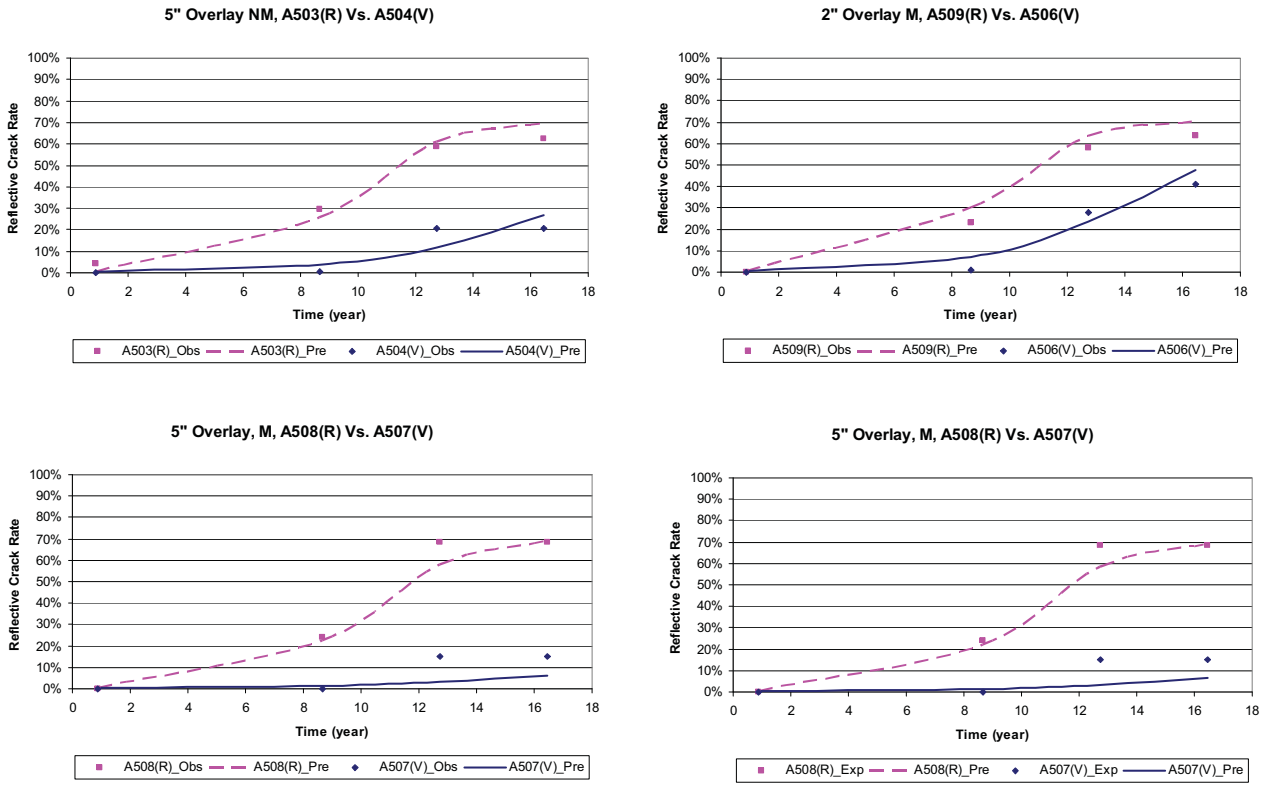


Fig. 11 Comparisons of the Virgin and RAP Sections with Both Field Observation and Model Prediction Using Eq. 3

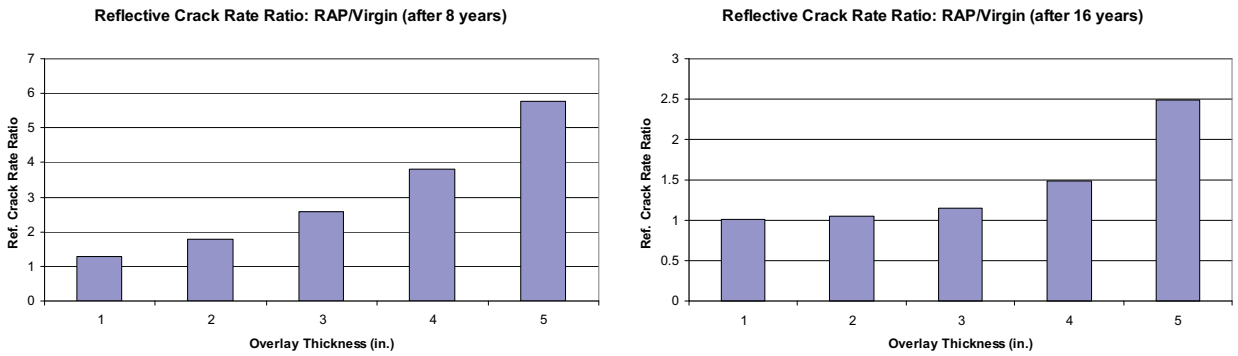


Fig. 12 Reflective Cracking Rate Ratio of RAP over Virgin Mixtures with Varying Overlay Thickness

APPENDIX C

SPS-5 FIELD REPORT
FOR NCHRP 9-30A

Texas SPS-5 Project

Construction Date:	9-25-1991	Elevation:	425
Route:	US-175	Latitude:	32.61
Functional Class:	2	Longitude:	-96.41
AADTT (Both Directions):	1220	Soil Type:	Fat Inorganic Clay

The Texas SPS-5 project is located in Kaufman County just southeast of Dallas, Texas on US Route 175 in the southbound traffic lane. US Route 175 is a four-lane divided highway.

Construction History:

- ➔ The existing flexible pavement was built in 1987.
- ➔ The HMA overlay was placed in 1991 and opened to traffic in September 1991.
- ➔ Construction Issues: Project was initially delayed because of rain, mix design problems, and receiving production plant parts. The air voids reported during construction are low, especially for the virgin mixture.
- ➔ No maintenance or rehabilitation was applied to pavement within the monitoring period for measuring rut depths.
- ➔ The SPS-5 project was taken out of service in September 2008.

Pavement Cross Section:

The layer thicknesses were extracted from the LTPP database, along with the volumetric data at the time of construction. Table TX-1 summarizes the pavement cross section for each test section (from LTPP Data Table L05B).

Table TX-1. Summary of Average Layer Thickness from LTPP Database

Test Section	Layer Type and Thickness						
	HMA Overlay			Existing Pavement Layers			
	Mix Type	Wearing Surface	HMA Binder & Level Up	HMA Surface	HMA Binder	Lime Treated CS Base	Lime Treated Subgrade
0502	RAP Mix	2.2	---	1.3	7.9	14.6	8
0503	RAP Mix	2.1	3.2	1.4	8.0	12.4	8
0504	Virgin Mix	2.2	3.1	1.2	7.5	10.6	8
0505	Virgin Mix	2.0	---	1.5	8.0	15.0	8
0506	Virgin Mix/Mill	2.3	1.6	---	7.7	15.0	8
0507	Virgin Mix/Mill	2.0	5.0	---	7.7	15.0	8
0508	RAP Mix/Mill	2.1	5.2	---	8.3	14.6	8
0509	RAP Mix/Mill	2.2	2.1	---	7.8	14.6	8

The leveling course or lift is combined with the binder layer thickness within the LTPP database. The thickness of the individual lifts placed during overlay construction varied from about 1.5 to 2.5 inches. Thus, the lift thicknesses initially measured from the

trenches (discussed in a latter section of this report) did not agree with the LTPP database. Initially, this caused some concern and confusion on the specific layers of the overlay. After the leveling course was combined with the lower binder layer of the overlay, the thicknesses were much closer to those included in the LTPP database. All test sections are applicable and were included for comparing the different transfer functions and test procedures.

Material Properties Reported During Construction:

The average properties used in the rut depth predictions with the MEPDG are summarized at the end of this test section report. Those properties extracted from the LTPP database that were measured during construction and are being used to reconstitute the test specimens for the production test program are summarized below.

Aggregate Properties for HMA Overlay Mixtures:

- Type of aggregate included in the mixture design for both the RAP and virgin mixtures for the binder layer was granite screening, granite coarse aggregate, and field sand. The aggregates used in the wearing surface were different. The following lists the aggregate percentages used to establish the job mix formula for all mixtures used within this SPS-5 project.

Layer	Aggregate Type	Aggregate Percentages	
		RAP	Virgin
Binder & Leveling	Recycled HMA	35	0
	Type D Crushed Granite	10	30
	Type B Crushed Granite	33	23
	Granite Screenings	10	30
	Field Sand	12	17
Wearing Surface	Recycled HMA	35	0
	Type D Trap Rock	10	23
	Type C Trap Rock	28	27
	Granite Screenings	15	31
	Field Sand	12	19

- Fine Aggregate Angularity – Not Reported
- Fine Aggregate bulk specific gravity – 2.620
  - Specific gravity used for mixture design for the fine aggregate was 2.674 and 2.682.
- Fine Aggregate Absorption (water) – 0.88
  - Absorption of fine aggregate reported on the mixture design sheets was 0.3 percent.
- Coarse Aggregate Angularity – Not Reported
- Coarse Aggregate specific gravity – 2.763
  - Specific gravity used for mixture design for the different coarse aggregate was 2.728 and 2.784.
- Coarse Aggregate Absorption (water) – 0.55
  - Absorption of coarse aggregate reported on the mixture design sheets varied from 0.2 to 0.4 percent.

Mixture #1—RAP Mixture and Test Sections:

The mixture design sheets were reviewed and compared to the test results included in the LTPP database. Some significant deviations from the job mix formula (JMF) were noted for the RAP mixture. For example; the absorption values for the aggregate were found to be different, the LTPP gradation included much more fines that were outside the JMF specification limits, and the LTPP total asphalt content was much lower than designed in the laboratory. The values included in the LTPP database are being used to reconstitute the mixtures in the laboratory for production testing, which are listed below.

- Asphalt grade used in RAP mix – AC-5; Total Petroleum
- Anti-strip additive added to asphalt – 1.0 percent
    - The tensile strength ratio (TSR) exceeded the minimum value of 0.70 with the anti-strip added to the asphalt.
- Asphalt Specific Gravity – 1.031
    - Much higher than included on the mix design sheets; 1.011.
- Amount of RAP used in binder and surface – 35 percent
- Amount of asphalt in RAP material – 5 percent by weight
- RAP specific gravity – 2.482
- Bulk specific gravity of aggregate blend – 2.671
    - The bulk specific gravity of aggregate used in mixture design was 2.631
- Effective specific gravity of aggregate – 2.702
- Total asphalt content by weight – 4.1
    - The target asphalt content to be added was 2.0 percent (for a coarser aggregate blend) which resulted in a total asphalt content (including the RAP material) of 3.8 percent.
- Maximum Specific Gravity of RAP mix – 2.534
    - The maximum specific gravity at the target asphalt content reported on the mixture design sheet was 2.514.
- Voids in Mineral Aggregate – 13.0
    - The VMA at the target asphalt content from the mixture design sheet was 9.7 percent.
- Average Air Voids at construction – 4.42
- Aggregate Blend for the RAP Mixture:
    - The percent passing values for the smaller aggregate particles included in the LTPP database are significantly higher than the JMF. For example; the percent passing the #200 sieve was 1.7 percent, 7.3 percent for the #80 sieve, 33.2 percent for the #10 sieve, and 69.6 percent for the #3/8 sieve from the JMF. The following percent passing values are averages from the LTPP database.

Sieve Size	1 ½	1	¾	½	3/8	#4	#10	#40	#80	#200
Binder Mix	100	100	99	85	75	55	40	27.4	13.0	6.0
Surface			No test data reported.							

Mixture #2—Virgin Mixtures and Test Sections:

- Asphalt grade used in virgin mix – AC-10 with 3 percent latex (pre-mixed)
- Anti-strip additive added to asphalt – 1.0 percent
  - The TSR reported on the mixture design sheet with the anti-strip added to the asphalt was 0.66—less than the minimum value of 0.70. [NOTE: Refer to cores shown in the forensic investigation included in a latter part of this report. Cores show signs of stripping but in the existing HMA and in lower lift of the HMA overlay.]
- Asphalt Specific Gravity – 1.034
  - Specific gravity from the mixture design sheet was 1.04.
- Bulk specific gravity of aggregate blend – 2.694
- Effective specific gravity of aggregate – 2.748
- Total asphalt content by weight – 4.5
  - The target asphalt content was 4.8 percent (for a coarser aggregate blend).
- Maximum Specific Gravity – 2.557
  - The maximum specific gravity reported on the mix design sheets at the target asphalt content was 2.505.
- Voids in Mineral Aggregate of virgin mix – 12.5
  - The VMA at the target asphalt content from the mixture design sheet was 14.4 percent.
- Average Air Voids – 2.66
- Aggregate Blend for the Virgin Mixture:
  - The percent passing values for the smaller aggregate particles included in the LTPP database are significantly higher than the JMF. For example; the percent passing the #200 sieve was 2.1 percent, 7.9 percent for the #80 sieve, 36.6 percent for the #10 sieve, and 72.4 percent for the #3/8 sieve from the JMF. The following percent passing values are averages from the LTPP database.

Sieve Size	1 ½	1	¾	½	3/8	#4	#10	#40	#80	#200
Binder	100	100	98	91	80	57	43	27.3	14.3	6.4
Surface	100	100	100	83	73	51	39	27.0	11.7	5.6

Existing HMA Layer/Mixture:

- Asphalt Specific Gravity – 1.056
- Asphalt Content by Weight – 4.75
- Maximum Specific Gravity – 2.439
- Air Voids – 2.64
- Aggregate Blend for the Two Layers/Mixtures, percent passing:

Sieve Size	1 ½	1	¾	½	3/8	#4	#10	#40	#80	#200
Binder	99	89	80	72	67	58	41	24.7	13.7	6.0
Surface	100	100	100	100	97	62	34	24.3	11.0	4.3

An important observation related to this project is that the viscosities recorded in the LTPP database during construction are high for the virgin mix—exceeding 300,000 poises. For this stiff asphalt, the rut depths should be minimal—which is not the case.

Analysis of Measured Rut Depths:

The average rut depths measured over time and extracted from the LTPP database for each test section are included at the end of this tests section report. The maximum rut depths measured along the individual test sections varied from 0.236 (RAP mixture) to 0.472 (virgin mixture) inches—a significant difference between the test sections.

Figure TX-1 shows the measured rut depths as a function of time for the two sections that were trenched, while figure TX-2 shows the measured rut depths as a function of time for all test sections within the SPS-5 project. As shown, mixture type (RAP versus virgin mixes) has a definite effect on the magnitude of the measured rut depths. Another important observation from this time-series data is the amount of variability in the measured rut depths for an individual test section.

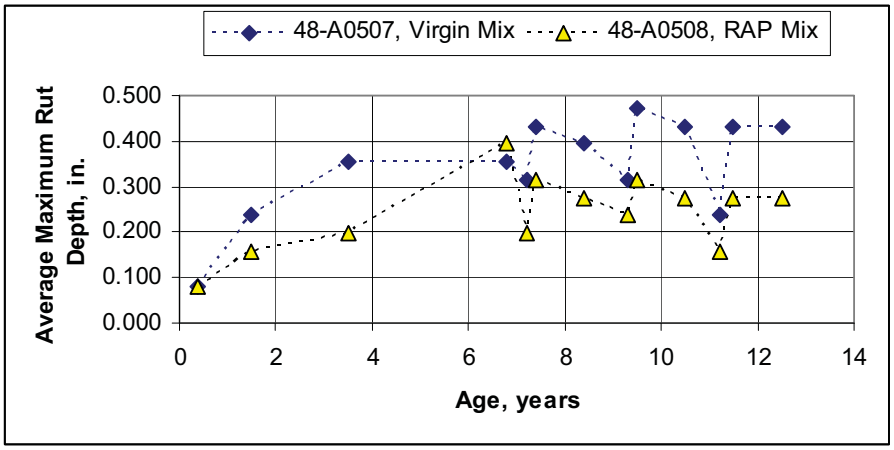


Figure TX-1. Average Maximum Rut Depths Measured with Time for Sections 48-A0507 and A0508

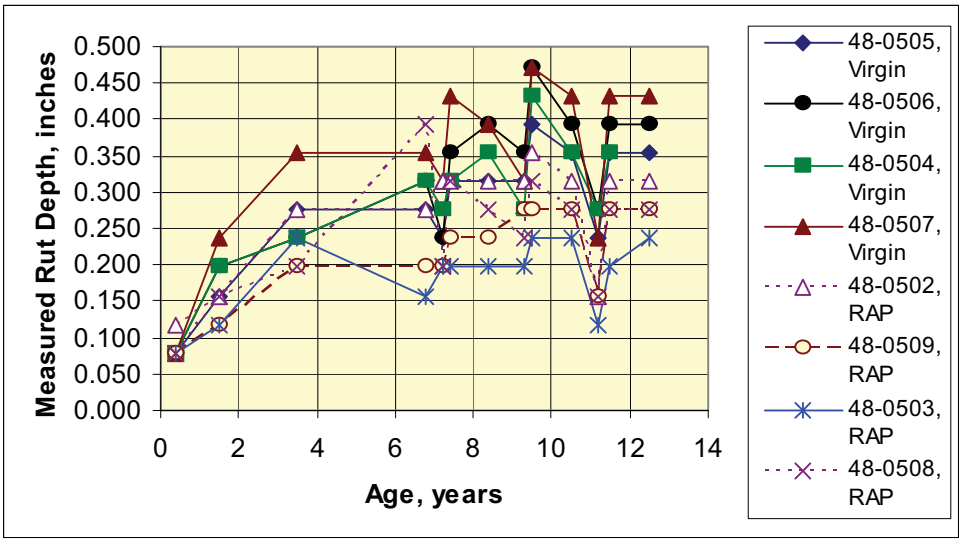


Figure TX-2. Rut Depths Measured Over Time for Each SPS-5 Test Section

The following lists the average maximum rut depths measured on the sections with the different HMA mixtures (RAP versus virgin mixes).

Statistical Parameter	RAP Mixtures	Virgin Mixtures
Mean Max. Rut Depth, in.	0.296	0.443
Standard Deviation, in.	0.0507	0.0373
Coefficient of Variation, %	17.2	8.4

Figure TX-3 shows the effect of HMA overlay thickness and mixture type on the maximum rut depth measured along each of the SPS-5 test sections. As shown, the test sections with the RAP mixtures have rut depths consistently less than those measured along the sections with the virgin mixtures. HMA overlay thickness has no impact or systematic effect on the rut depths for this SPS-5 project. As noted above, the asphalt viscosities and penetration values recorded in the LTPP database for the virgin mixture suggest that this mixture is brittle and hard or stiff. The rut depths should be as low, if not lower than the RAP mixture, which is not the case. Thus, the Texas SPS-5 project was selected for the detailed forensic investigation.

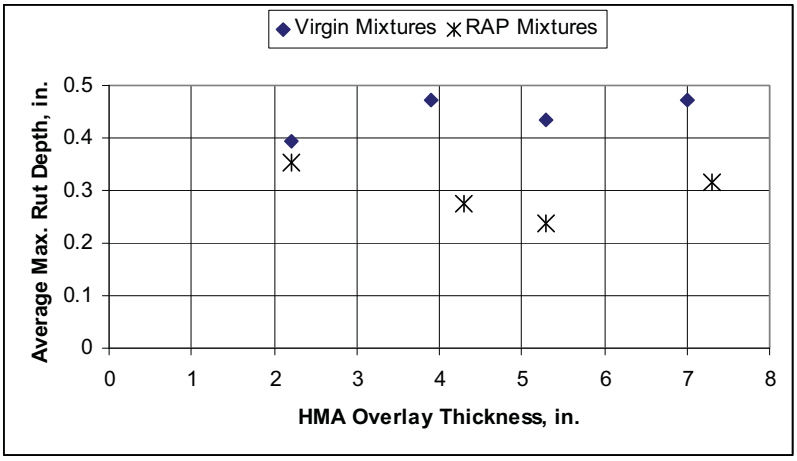


Figure TX-3. Effect of HMA Overlay Thickness and Mixture Type on Maximum Rut Depth

Forensic Investigation of Texas SPS-5 Project:

Two trenches were excavated along this SPS-5 project to determine the amount of rutting within each HMA layer for a section with virgin mixtures and one with RAP mixtures. ARA engineers Paul Littleton and Harold Von Quintus were on site to collect pavement layer thickness measurements from the right wheel path of two SPS5 test sections; 48A507 and 48A508. ARA was assisted by Robert James of Burns Cooley Dennis, Inc.

Trenching was originally excluded from the LTPP forensic investigation, but the Texas Department of Transportation (TexDOT) agreed with ARA that this information would be valuable for investigating the rutting behavior of these overlay mixtures. ARA and TexDOT excavated two trenches; one in a section with the RAP mixture and the other in a section with the virgin mixture. Dr. Feng Hong of TexDOT was on site to observe ARA take pavement layer measurements. Trench dimensions were 2 ft wide by 6 ft long

positioned from the outer lane edge to the center of the lane. The trenches were excavated to the depth of the original pavement, approximately 7-inches. Figures TX-4 and TX-5 show the trenches within each section.

Section 48A507 was designed to be a 5-in overlay comprised of 2-in virgin HMA surface course over a 3-in binder layer. Section 48-A508 was designed to be a 5-in virgin HMA overlay comprised of 2-in surface course over 3-in binder. Both sections were paved on top of a 2-in leveling course to smooth out roughness caused by milling.

Six 6-in diameter cores were drilled by the Texas Transportation Institute (TTI) and recovered from both sections. These cores will be tested in the laboratory using the RSCH test to determine the effect of aging on the permanent deformation parameters and to determine the difference between the in place RAP and virgin mixtures. The binder used in the virgin mixture was latex modified asphalt. Latex was not used within the binder for the RAP mixture, so it looks drier and exhibited much less rutting.

Most of the cores were recovered intact but there were some that broke at the interface between the HMA overlay or leveling course and existing HMA surface. More importantly, some cores that were taken by TTI exhibited stripping and moisture damage during the wet coring operation. These were in other sections but do indicate that moisture damage was present in the existing HMA layers and/or lower lift of the HMA overlay. None of the HMA overlay mixtures, however, exhibited stripping or moisture damage during the coring process of the two sections where the trenches were excavated.

Measurements were taken from the pavement surface to a string line stretched taught across the surface of the pavement. Additional string lines were located at each interface between the HMA lifts. These string lines were used to easily locate the interface between the different lifts or layers. All layer thickness measurements were taken at the interface between the layers and not the string line itself. In most cases, the interface could be easily identified. The string lines in place and the equipment used to measure the layer thickness at different points across the face of the trench.

The thicknesses measured across the HMA overlay lifts are believed to be related to construction deviations. In other words, some of the thickness variations could be related to construction deviations, and it is certainly possible for the gradual change in thickness across the trench to have been caused by the crown settings of the screed, and/or lateral slope of the screed and screed extensions of the paver.

The thickness profiles of the leveling course and first binder lift have opposite slopes in thickness versus paving width. This difference could have been caused by the crown settings of the paver. In other words, the paver could be correcting the slopes from one lift to another.

From these figures, it would appear that the rutting in section 48-A0508 is confined to the surface RAP layer, with a maximum of 0.25 in. Immeasurable rutting was found within the lower layers of the RAP overlay. For section 48A507, rutting has occurred within the surface layer of the virgin HMA with a maximum of about 0.2 in. centered in the wheel path, and continues into the bottom of the binder layer (leveling lift) to a magnitude of about 0.2 in. As noted previously, the lower lift of the virgin mix for binder layer or leveling course was reported to have tensile strength ratios (TSR) lower than the minimum required value of 0.70. Some of this rutting in the leveling course could be associated with moisture damage within that layer. The TSR values reported for the RAP mixtures all exceeded the minimum value of 0.70 and no measurable rut depths were found within that layer from the trench in section 48-A0508.

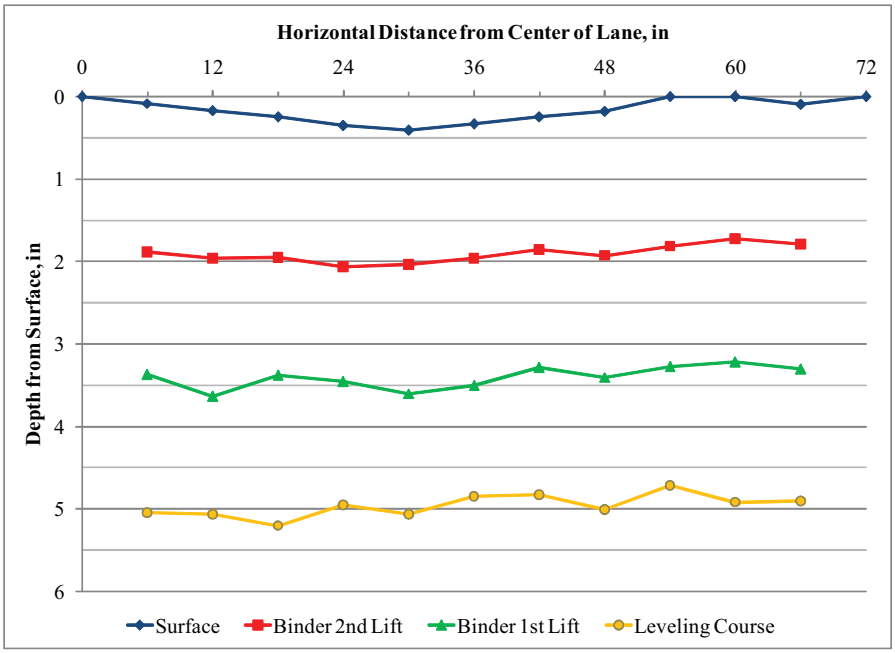


Figure TX-10. Section 48A507 Virgin HMA Overlay

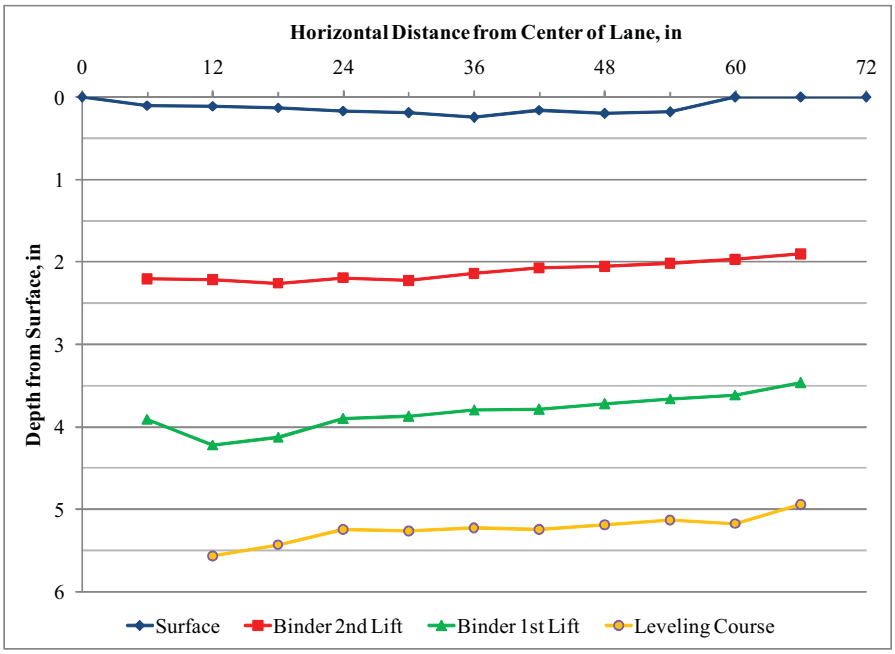


Figure TX-11. Section 48A508 RAP Overlay

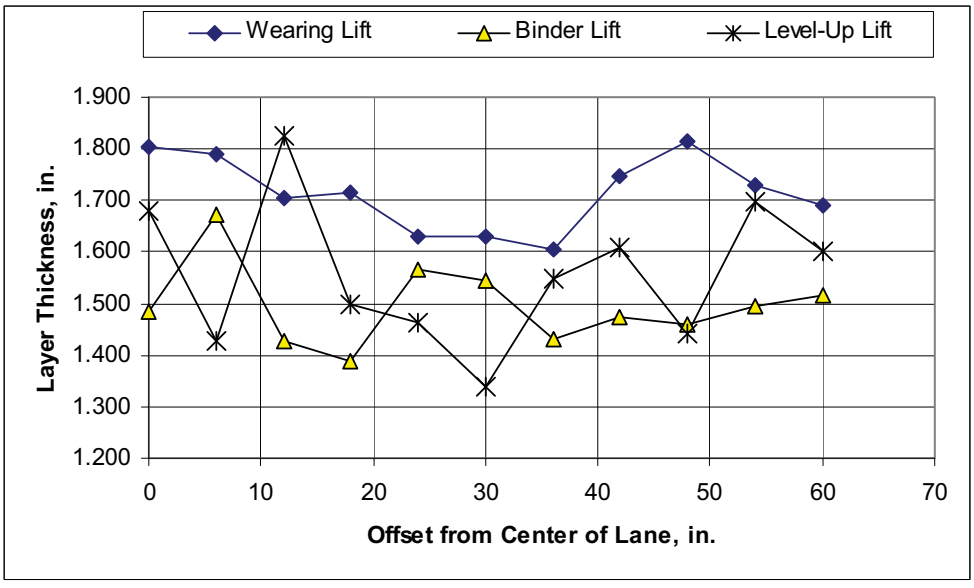


Figure TX-12. Layer or Lift Thickness Measurements Taken Along the Cut Face of the Trench Excavated for Section 48-A0507 with the Virgin Mixture

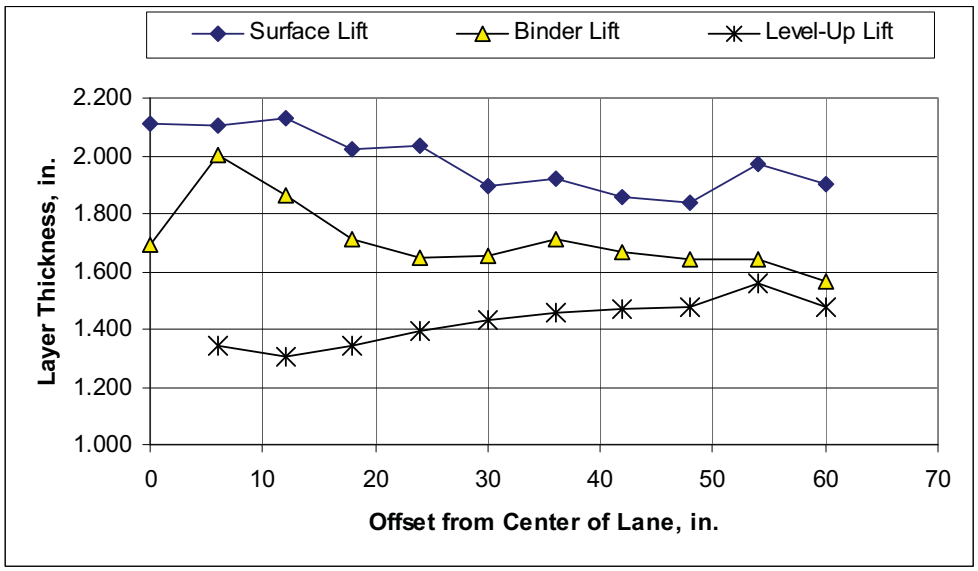


Figure TX-13. Layer or Lift Thickness Measurements Taken Along the Cut Face of the Trench Excavated for Section 48-A0508 with the RAP Mixture

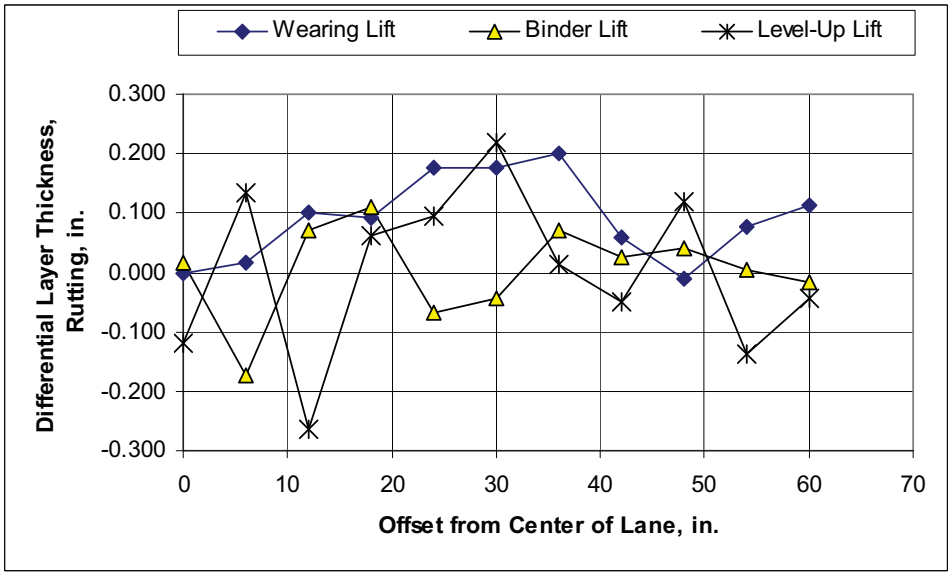


Figure TX-14. Differential Layer Thickness Measured Along the Cut Face of the Trench for Section 48-A0507 with the Virgin Mixture

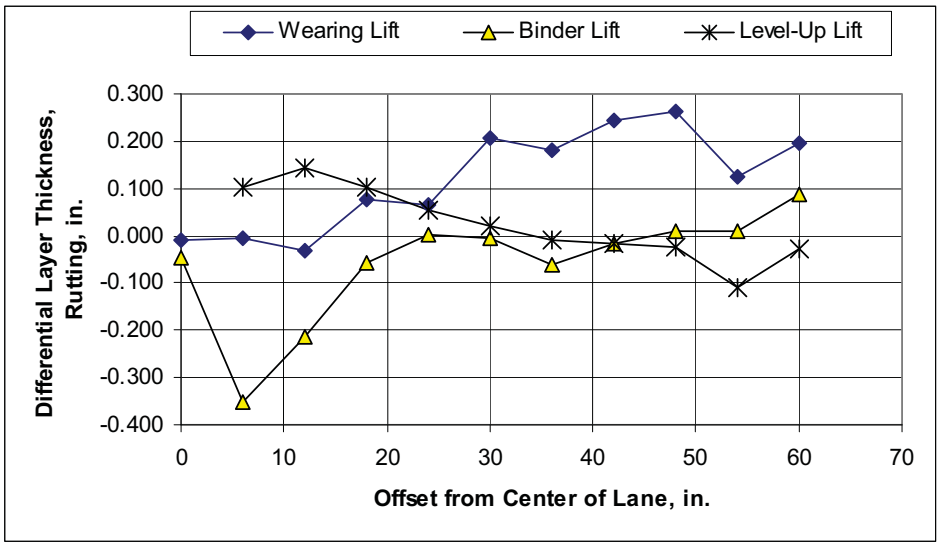


Figure TX-15. Differential Layer Thickness Measured Along the Cut Face of the Trench for Section 48-A0508 with the RAP Mixture

In summary, most of the rutting has occurred within the HMA overlay wearing surface. It is difficult to determine the actual magnitude of rutting within each of the HMA overlay lifts for these two sections. Three lifts were placed for the overlay; the wearing surface, the binder layer and a leveling course. Table TX-1 excludes the leveling course that was placed prior to overlay.

➔ Based on an analysis of the measured rut depths, all measurable rutting has occurred in the HMA overlay—most of the rutting has occurred within the wearing surface of both sections. Thus, both the RAP and virgin mixtures should be tested because of the difference in magnitudes of the rut depths. It is expected that immeasurable rutting has occurred in the existing HMA and other lower layers.

Rut Depth Transfer Functions and Prediction Models

The following sections provide results from the rut depths predicted by different versions of the MEPDG, as listed below. [Most of the runs will be made after the revisions and changes have been verified for the MEPDG that were discussed at the June 22, 2008 NCHRP panel meeting. Theses revisions and changes should be verified by the end of October.]

1. No modifications or changes to the MEPDG rut depth transfer function; the global permanent deformation constants of the transfer function are mixture or layer independent; rut depths are explained by variations in dynamic modulus (input level 3).
    a. MEPDG vertical strain transfer function.
    b. Verstraeten deviator stress transfer function.
    c. Asphalt Institute vertical strain and deviator stress transfer function.

2. Permanent deformation constants of the transfer functions are mixture dependent but based on global values (input level 3).
    a. Use of the WesTrack shear strain and stress transfer function with permanent deformation values that are layer independent.
3. Permanent deformation constants of the transfer function are layer or mixture dependent; all of the following versions will be made with the revised software (input level 2):
    a. Use of the NCHRP Project 1-40B mixture adjustment values to revise the permanent deformation constants of the MEPDG vertical strain transfer function.
    b. Use of the WesTrack shear strain and stress transfer function with permanent deformation values that are layer dependent and determined from the volumetric parameters, similar to the NCHRP 1-40B mixture adjustment values.
4. Use of laboratory repeated load permanent deformation values that are layer dependent (input level 1); all of the following versions will be made with the revised software:
    a. MEPDG vertical strain transfer function.
    b. Asphalt Institute vertical strain and deviator stress transfer function.
    c. Verstraeten deviator stress transfer function.
    d. WesTrack shear strain and stress transfer function.

NOTE:
The following part of the test section report is incomplete because of the changes being made to the MEPDG. It is simply an outline of the information that will be included in the report once all of the program changes and alterations have been completed and verified.

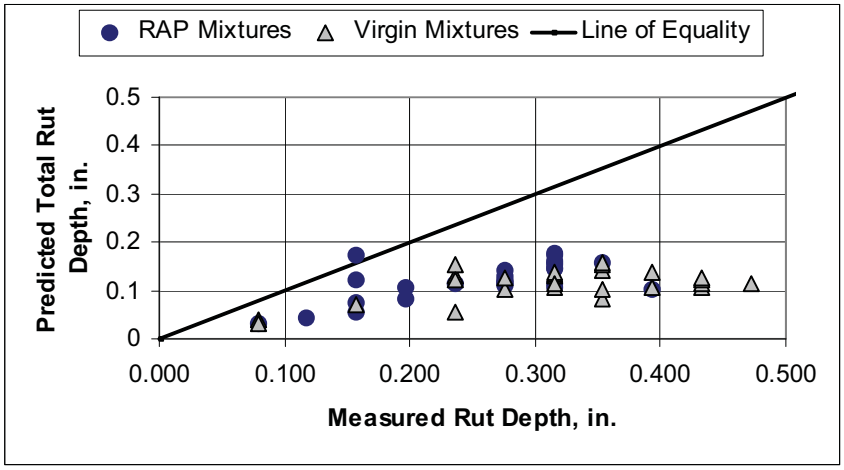
Predicted Rut Depths—Global Calibration Values for Vertical Strain Transfer Function

The rut depths were predicted using the MEPDG global calibration values. A summary of the inputs for the MEPDG is included at the end of this test section report.

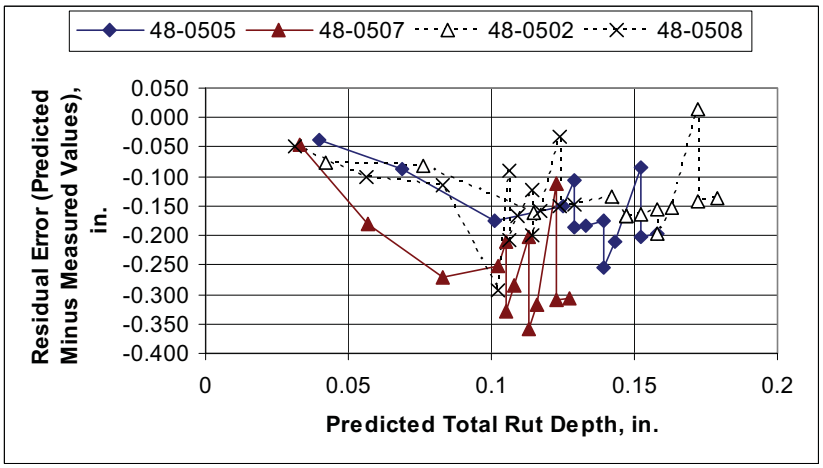
The MEPDG was used to predict the rut depths for each section using the global calibration parameters. Figure TX-16(a) compares the measured and predicted rut depths using the global calibration values for the MEPDG vertical strain transfer function. As shown, the MEPDG consistently under predicts the rut depths—a negative bias. It is expected that the majority of the rutting has occurred in the HMA overlay mixtures, which was confirmed with the trench.

A comparison of the residual errors and predicted rut depths is shown in figure TX-16(b). As shown, there is significant deviation between the measured and predicted rut depths and the residual error is highly variable. The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the global calibration values for the vertical strain transfer function, which assumes that the permanent deformation parameters are layer independent (refer to figure TX-16).

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =



(a) Measured versus predicted rut depths.



(b) Predicted versus residual errors.

Figure TX-16. Comparison of the Predicted and Measured Rut Depths and Residual Error Using the MEPDG Global Calibration Values for the SPS-5 Project

Predicted Rut Depths—NCHRP Project 1-40B Mix Adjustment Values for the Vertical Strain Transfer Function:

The NCHRP Project 1-40B mixture adjustment parameters were used to estimate the permanent deformation constants for the different mixtures and layers of the Texas SPS-5 project. The values estimated for each layer are included at the end of this test section

report. The equivalent permanent deformation constants were determined for the entire HMA overlay thickness using the equivalent thickness method suggested in NCHRP Project 1-40B.

The HMA mixture designs were provided by LTPP for review for the different HMA overlay mixtures to estimate the NCHRP Project 1-40B mixture adjustment factors. The mixture adjustment factors, however, need to represent the in place mixture volumetric properties at construction. Thus, the HMA volumetric and aggregate properties were extracted from the LTPP database. Plots of the average gradation were prepared for estimating the rut depth mixture adjustment factors in accordance with the procedure identified in NCHRP Project 1-40B.

Figure TX-17 compares the predicted and measured rut depths using the NCHRP 1-40B mixture adjustment factors, as well as comparing the predicted rut depths to the residual errors. As shown, most of the bias resulting from the global values (refer to figure TX-16) has been removed and the standard error was reduced; BUT—there is still a negative bias between the measured and predicted values. The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the global calibration values for the vertical strain transfer function (refer to figure TX-17).

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

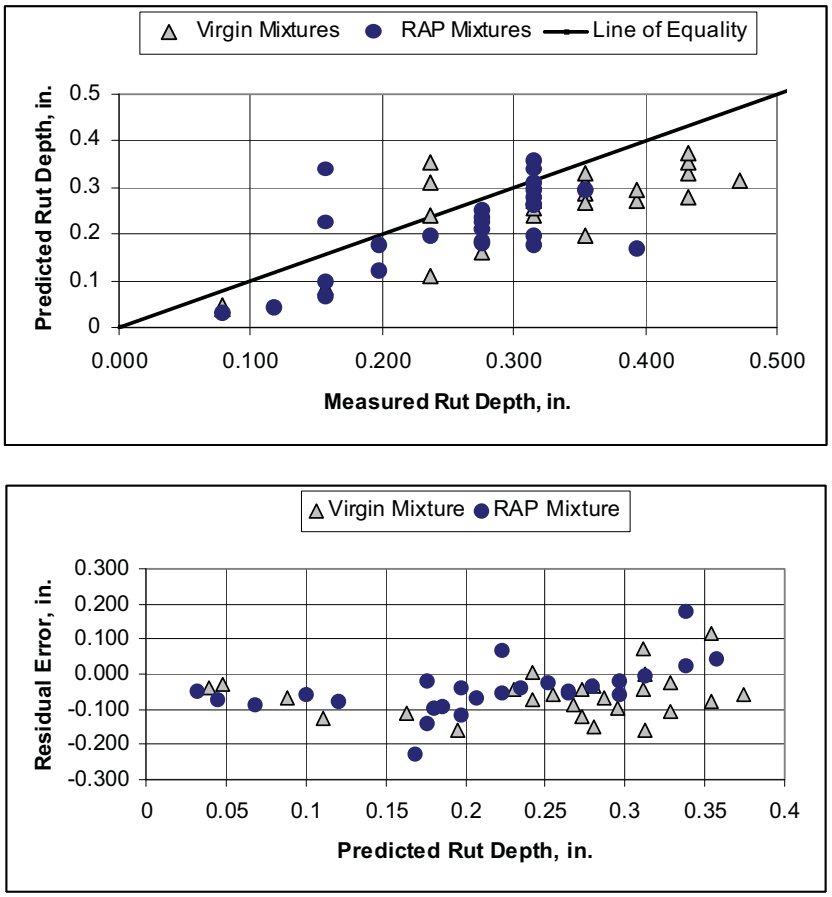


Figure TX-17. Comparison of the Predicted and Measured Rut Depths and Residual Error Using the NCHRP 1-40B Mix Adjustment Values for the SPS-5 Sections

Other Transfer Functions—Global Calibration Values

Figures TX-18 and TX-19 show similar trends between the predicted and measured rut depths for the other transfer functions included in the MEPDG—Verstraeten deviator stress transfer function and WesTrack shear strain and stress transfer function.

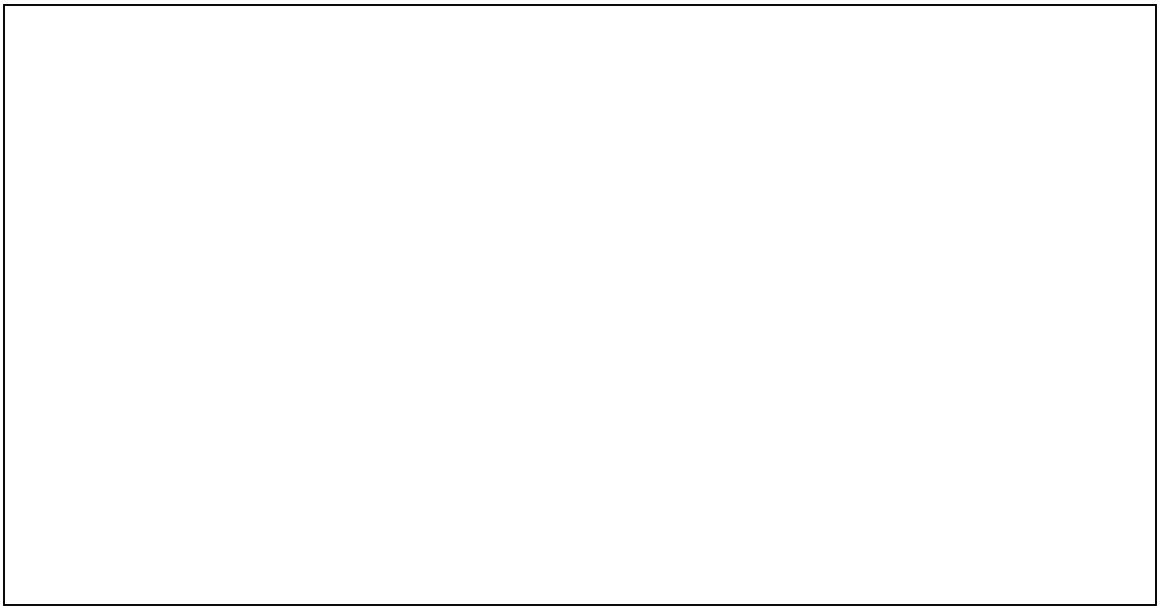


Figure TX-18. Comparison of the Predicted and Measured Rut Depths and Residual Error Using the Global Values for the Verstraeten Deviator Stress Transfer Function for the SPS-5 Sections

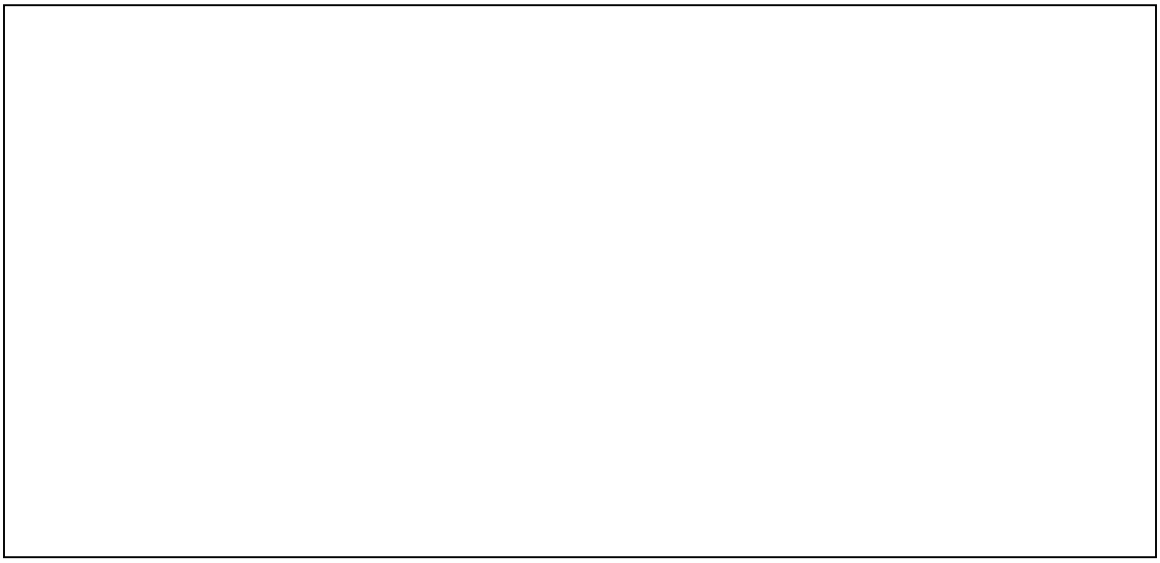


Figure TX-19. Comparison of the Predicted and Measured Rut Depths and Residual Error Using the Global Values for the WesTrack Shear Strain and Stress Transfer Function for the SPS-5 Sections

MEPDG Vertical Strain Transfer Function Including Deviator Stress

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the global calibration values for the vertical strain and deviator stress transfer function.

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

Verstraten Deviator Stress Transfer Function

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the global calibration values for the deviator stress transfer function.

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

WesTrack Shear Strain and Stress Transfer Function

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the global calibration values for the shear strain and stress transfer function.

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

Rut Depths Predicted Using Laboratory Repeated Load Permanent Deformation Tests

This section of the report summarizes the comparison of the predicted and measured rut depths using laboratory permanent deformation test results in support of the different rut depth transfer functions. Figures TX-XX and TX-YY show the results from the laboratory tests to determine the permanent deformation constants using different transfer functions.

MEPDG Vertical Strain Transfer Function

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the permanent deformation constants determined from the laboratory testing for the vertical strain transfer function (repeated load triaxial tests) that are mixture or layer dependent.

- ➔ Bias =
- ➔ SEE =

- ➔ R2 =
- ➔ Se/sy =

Asphalt Institute Vertical Strain with Deviator Stress Transfer Function

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the permanent deformation constants determined from the laboratory testing in accordance with the vertical strain and deviator stress transfer function (repeated load triaxial tests) that are mixture or layer dependent.

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

Verstraeten Deviator Stress Transfer Function

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the permanent deformation constants determined from the laboratory testing in accordance with the deviator stress transfer function (repeated load triaxial tests) that are mixture or layer dependent.

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

WesTrack Shear Strain and Stress Transfer Function

The following summarizes the statistical parameters for the comparison between the measured and predicted rut depths using the permanent deformation constants determined from the laboratory testing in accordance with the shear strain and shear stress transfer function (repeated shear, constant height tests) that are mixture or layer dependent.

- ➔ Bias =
- ➔ SEE =
- ➔ R2 =
- ➔ Se/sy =

Analysis of Results, Predicted Versus Measured Rut Depths:

The following summarizes the results of the comparisons between the predicted and measured rut depths using the different transfer functions and test procedures. These values will change based on the revisions and alterations being made to the MEDPG for NCHRP Project 9-30A version.

Transfer Function	Mixture Type	Statistical Parameters			
		Bias, in.	SEE, in.	R2	Se/sy
Global Parameters	RAP Mixes	-0.084	0.097	<0	1.614
	Virgin Mixes				
Mix Adjust. Parameters	RAP Mixes	-0.031	0.0642	0.36	0.767
	Virgin Mixes				
RLPD; Vertical Strain	RAP Mixes				
	Virgin Mixes				
RLPD; Deviator Stress	RAP Mixes				
	Virgin Mixes				
RSCH; shear strain & stress	RAP Mixes				
	Virgin Mixes				

DETERMINATION OF NCHRP 1-40B ADJUSTMENT FACTORS FOR PREDICTING RUT DEPTHS

Project Identification: **Texas SPS-5 Project - Binder and Surface Layers**

Layer Identification		Binder Layer		Wearing Surface		Existing Layers	
		RAP Mix	Virgin Mix	RAP Mix	Virgin Mix	Binder	Surface
Bulk Specific Gravity	G_{mb}	2.422	2.489	2.422	2.489	2.3577	2.3916
Maximum Specific Gravity	G_{mm}	2.534	2.5567	2.534	2.5193	2.412	2.4657
Air Voids, %	V_a	4.42	2.65	4.42	1.20	2.25	3.01
Air Voids for Target Asphalt Content, %	$V_{a(design)}$	4.00	4.00	4.00	4.00	4.00	4.00
Total Asphalt Content by Weight, %	P_b	4.10	4.50	4.10	5.00	4.70	4.80
Optimum/Saturation Asphalt Content, %	$P_{b(0pt)}$	4.50	4.50	4.80	5.20	4.70	4.80
Aggregate Effective Specific Gravity	G_{se}	2.702	2.747	2.702	2.724	2.576	2.642
Bulk Specific Gravity of Aggregate Blend	G_{sb}	2.671	2.715	2.671	2.692	2.548	2.613
Effective Asphalt Content by Volume, %	V_{be}	8.618	9.798	8.618	10.964	9.572	9.863
Voids in Mineral Aggregate, %	VMA	13.0	12.4	13.0	12.2	11.8	12.9
Voids Filled with Asphalt, %	VFA	66.1	78.7	66.1	90.1	81.0	76.6
Gradation Factor (GI Term)	K_{r3}	0.70	0.70	0.70	0.70	0.70	0.40
Fine Aggregate Factor	F_{index}	1.05	1.05	1.05	1.05	1.00	1.00
Coarse Aggregate Factor	C_{index}	0.90	0.90	0.90	0.90	1.00	1.00
Log Kr1		2.40	2.95	2.43	3.80	3.10	3.80
Rut Depth Coefficient	k_{r1}	-2.593	-2.103	-2.563	-1.382	-2.000	-1.221
Temperature Exponent	k_{r2}	1.346	1.330	1.242	1.040	1.352	1.453
Traffic Loadings Exponent	k_{r3}	0.306	0.335	0.286	0.322	0.335	0.192

Asphalt Specific Gravity	G_b	1.031	1.034	1.031	1.038	1.052	1.06
Kr1 Value		251.18864	891.25094	269.15348	6309.5734	1258.925412	6309.5734
Absorbed Asphalt by Weight, %		0.45	0.45	0.45	0.45	0.45	0.45
kr1 Log Value		7.1772552	22.18262	7.69056749	116.53961	28.1256691	168.88162

NOTE: An anti-strip additive of 1 percent was added to the asphalt, but the Virgin mixture exhibited signs of stripping in a few cores and the mix design sheets reported a TSR value of 0.66 for the virgin mixture and 0.79 for the RAP mixture. The minimum value required was 0.70.

NOTE: Bulk specific gravities were not reported in the LTPP database for the wearing surface of the sections with the RAP and virgin mixtures. It was simply assumed that the bulk specific gravities would be similar to those of the binder and level up layers. In addition, maximum specific gravities were not reported for the wearing surface of the RAP mixtures or test sections.

Note: The mixture design information was not used to determine the saturation asphalt content, because of the difference in gradation between the values included in the LTPP database and mix design sheets. The value included above was based on other designs and information for the granite aggregate with a finer aggregate blend.

AVERAGE RUT DEPTH MEASUREMENTS EXTRACTED FROM LTPP DATABASE FOR THE TEXAS SPS-5 PROJECT

LTPP Data Element: **MAX_MEAN_DEPTH_WIRE_REF**

Section	Date	Age, years	Rut Depth, in.
48-0505.	28-Jan-92	0.4	0.079
48-0505.	03-Mar-93	1.5	0.157
48-0505.	09-Mar-95	3.5	0.276
48-0505.	04-Jun-98	6.8	0.276
48-0505.	05-Nov-99	7.2	0.236
48-0505.	27-Apr-00	7.4	0.315
48-0505.	16-May-01	8.4	0.315
48-0505.	10-Jan-02	9.3	0.315
48-0505.	05-Apr-02	9.5	0.394
48-0505.	24-Apr-03	10.5	0.354
48-0505.	02-Dec-03	11.2	0.236
48-0505.	17-Mar-04	11.5	0.354
48-0505.	09-Mar-05	12.5	0.354
48-0506.	28-Jan-92	0.4	0.079
48-0506.	03-Mar-93	1.5	0.197
48-0506.	09-Mar-95	3.5	0.236
48-0506.	04-Jun-98	6.8	0.315
48-0506.	05-Nov-99	7.2	0.236
48-0506.	27-Apr-00	7.4	0.354
48-0506.	16-May-01	8.4	0.394
48-0506.	10-Jan-02	9.3	0.354
48-0506.	05-Apr-02	9.5	0.472
48-0506.	23-Apr-03	10.5	0.394
48-0506.	02-Dec-03	11.2	0.276
48-0506.	17-Mar-04	11.5	0.394
48-0506.	09-Mar-05	12.5	0.394
48-0504.	28-Jan-92	0.4	0.079
48-0504.	03-Mar-93	1.5	0.197
48-0504.	09-Mar-95	3.5	0.236
48-0504.	03-Jun-98	6.8	0.315
48-0504.	05-Nov-99	7.2	0.276
48-0504.	26-Apr-00	7.4	0.315
48-0504.	16-May-01	8.4	0.354
48-0504.	10-Jan-02	9.3	0.276
48-0504.	05-Apr-02	9.5	0.433
48-0504.	23-Apr-03	10.5	0.354
48-0504.	02-Dec-03	11.2	0.276
48-0504.	17-Mar-04	11.5	0.354
48-0507.	28-Jan-92	0.4	0.079
48-0507.	03-Mar-93	1.5	0.236
48-0507.	09-Mar-95	3.5	0.354
48-0507.	03-Jun-98	6.8	0.354
48-0507.	05-Nov-99	7.2	0.315
48-0507.	27-Apr-00	7.4	0.433
48-0507.	16-May-01	8.4	0.394
48-0507.	10-Jan-02	9.3	0.315
48-0507.	05-Apr-02	9.5	0.472
48-0507.	23-Apr-03	10.5	0.433
48-0507.	02-Dec-03	11.2	0.236
48-0507.	17-Mar-04	11.5	0.433
48-0507.	09-Mar-05	12.5	0.433

48-0502.	28-Jan-92	0.4	0.118
48-0502.	03-Mar-93	1.5	0.157
48-0502.	09-Mar-95	3.5	0.276
48-0502.	03-Jun-98	6.8	0.276
48-0502.	05-Nov-99	7.2	0.315
48-0502.	26-Apr-00	7.4	0.315
48-0502.	15-May-01	8.4	0.315
48-0502.	10-Jan-02	9.3	0.315
48-0502.	04-Apr-02	9.5	0.354
48-0502.	23-Apr-03	10.5	0.315
48-0502.	02-Dec-03	11.2	0.157
48-0502.	16-Mar-04	11.5	0.315
48-0502.	08-Mar-05	12.5	0.315
48-0509.	28-Jan-92	0.4	0.079
48-0509.	03-Mar-93	1.5	0.118
48-0509.	09-Mar-95	3.5	0.197
48-0509.	03-Jun-98	6.8	0.197
48-0509.	05-Nov-99	7.2	0.197
48-0509.	26-Apr-00	7.4	0.236
48-0509.	15-May-01	8.4	0.236
48-0509.	10-Jan-02	9.3	0.276
48-0509.	04-Apr-02	9.5	0.276
48-0509.	23-Apr-03	10.5	0.276
48-0509.	02-Dec-03	11.2	0.157
48-0509.	16-Mar-04	11.5	0.276
48-0509.	08-Mar-05	12.5	0.276
48-0503.	28-Jan-92	0.4	0.079
48-0503.	03-Mar-93	1.5	0.118
48-0503.	09-Mar-95	3.5	0.236
48-0503.	03-Jun-98	6.8	0.157
48-0503.	05-Nov-99	7.2	0.197
48-0503.	26-Apr-00	7.4	0.197
48-0503.	16-May-01	8.4	0.197
48-0503.	10-Jan-02	9.3	0.197
48-0503.	04-Apr-02	9.5	0.236
48-0503.	23-Apr-03	10.5	0.236
48-0503.	02-Dec-03	11.2	0.118
48-0503.	16-Mar-04	11.5	0.197
48-0503.	09-Mar-05	12.5	0.236
48-0508.	28-Jan-92	0.4	0.079
48-0508.	03-Mar-93	1.5	0.157
48-0508.	09-Mar-95	3.5	0.197
48-0508.	03-Jun-98	6.8	0.394
48-0508.	05-Nov-99	7.2	0.197
48-0508.	26-Apr-00	7.4	0.315
48-0508.	15-May-01	8.4	0.276
48-0508.	10-Jan-02	9.3	0.236
48-0508.	04-Apr-02	9.5	0.315
48-0508.	23-Apr-03	10.5	0.276
48-0508.	02-Dec-03	11.2	0.157
48-0508.	16-Mar-04	11.5	0.276
48-0508.	08-Mar-05	12.5	0.276

MEPDG INPUT SUMMARY
Texas SPS-5 Test Section Example

The following is a summary of the inputs that were used for the MEDPG runs using version 1.0. These runs will be revised after the revisions have been completed and verified using the NCHRP 9-30A version of the MEDPG. These are provided as an example to document the data and information included for this SPS-5 project. One note, the traffic input values were not included in the LTPP database for this project. The AADTT input value was determined from other information provided by Texas DOT on this segment of highway.

Project: NCHRP1-40B_Texas SPS-502

General Information

Design Life	14 years
Existing pavement construction:	June, 1977
Pavement overlay construction:	September, 1991
Traffic open:	September, 1991
Type of design	Flexible

Description:
SPS-5

Analysis Parameters

Performance Criteria	Limit	Reliability
Initial IRI (in/mi)	71	
Terminal IRI (in/mi)	172	90
AC Surface Down Cracking (Long. Cracking) (ft/mile):	2000	90
AC Bottom Up Cracking (Alligator Cracking) (%):	25	90
AC Thermal Fracture (Transverse Cracking) (ft/mi):	1000	90
Chemically Stabilized Layer (Fatigue Fracture)	25	90
Permanent Deformation (AC Only) (in):	0.25	90
Permanent Deformation (Total Pavement) (in):	0.75	90
Reflective cracking (%):	100	

Location:	Kaufman County, Texas
Project ID:	SPS-5
Section ID:	A0502
	Principal Arterials - Others
Date:	3/2/2008
Station/milepost format:	Miles: 0.000
Station/milepost begin:	
Station/milepost end:	
Traffic direction:	East bound

Default Input Level

Default input level	Level 3, Default and historical agency values.

Traffic

Initial two-way AADTT:	1220
Number of lanes in design direction:	2
Percent of trucks in design direction (%):	55
Percent of trucks in design lane (%):	95
Operational speed (mph):	55

Traffic -- Volume Adjustment Factors

Monthly Adjustment Factors (Level 3, Default MAF)

Month	Vehicle Class									
	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
February	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
March	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
April	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
May	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
June	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
July	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
August	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
September	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
October	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
November	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
December	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Vehicle Class Distribution

(Level 3, Default Distribution)

AADTT distribution by vehicle class

Class 4	2.8%
Class 5	22.6%
Class 6	5.9%
Class 7	0.2%
Class 8	18.0%
Class 9	46.8%
Class 10	0.7%
Class 11	2.0%
Class 12	0.7%
Class 13	0.3%

Hourly truck traffic distribution

by period beginning:

Midnight	2.3%	Noon	5.9%
1:00 am	2.3%	1:00 pm	5.9%
2:00 am	2.3%	2:00 pm	5.9%
3:00 am	2.3%	3:00 pm	5.9%
4:00 am	2.3%	4:00 pm	4.6%
5:00 am	2.3%	5:00 pm	4.6%
6:00 am	5.0%	6:00 pm	4.6%
7:00 am	5.0%	7:00 pm	4.6%
8:00 am	5.0%	8:00 pm	3.1%
9:00 am	5.0%	9:00 pm	3.1%
10:00 am	5.9%	10:00 pm	3.1%
11:00 am	5.9%	11:00 pm	3.1%

Traffic Growth Factor

Vehicle Class	Growth Rate	Growth Function
Class 4	3.5%	Compound
Class 5	3.5%	Compound
Class 6	3.5%	Compound
Class 7	3.5%	Compound
Class 8	3.5%	Compound
Class 9	3.5%	Compound
Class 10	3.5%	Compound
Class 11	3.5%	Compound
Class 12	3.5%	Compound
Class 13	3.5%	Compound

Traffic -- Axle Load Distribution Factors

Level 3: Default

Traffic -- General Traffic Inputs

Mean wheel location (inches from the lane marking):	18
Traffic wander standard deviation (in):	10
Design lane width (ft):	12

Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.62	0.39	0.00	0.00
Class 5	2.00	0.00	0.00	0.00
Class 6	1.02	0.99	0.00	0.00
Class 7	1.00	0.26	0.83	0.00
Class 8	2.38	0.67	0.00	0.00
Class 9	1.13	1.93	0.00	0.00
Class 10	1.19	1.09	0.89	0.00
Class 11	4.29	0.26	0.06	0.00
Class 12	3.52	1.14	0.06	0.00
Class 13	2.15	2.13	0.35	0.00

Axle Configuration

Average axle width (edge-to-edge) outside dimensions,ft):	8.5
Dual tire spacing (in):	12

Axle Configuration

Tire Pressure (psi) :	120

Average Axle Spacing

Tandem axle(psi):	51.6
Tridem axle(psi):	49.2
Quad axle(psi):	49.2

Climate

icm file: C:\DG2002\Projects\Texas SPS-5.icm

Latitude (degrees.minutes)	32.62
Longitude (degrees.minutes)	-96.43
Elevation (ft)	425
Depth of water table (ft)	12

Structure--Design Features

HMA E* Predictive Model:	NCHRP 1-37A viscosity based model.
HMA Rutting Model coefficients:	NCHRP 1-37A coefficients
Endurance Limit (microstrain):	None (0 microstrain)
Reflective cracking analysis:	Yes

Structure--Layers

Layer 1 -- Asphalt concrete

Material type:	Asphalt concrete
Layer thickness (in):	2.2

General Properties

General

Reference temperature (F°):	70

Volumetric Properties as Built

Effective binder content (%):	8.8
Air voids (%):	3.5
Total unit weight (pcf):	148
Poisson's ratio:	0.35 (user entered)

Thermal Properties

Thermal conductivity asphalt (BTU/hr-ft-F°):	0.67
Heat capacity asphalt (BTU/lb-F°):	0.23

Asphalt Mix

Cumulative % Retained 3/4 inch sieve:	2
Cumulative % Retained 3/8 inch sieve:	20
Cumulative % Retained #4 sieve:	43
% Passing #200 sieve:	6.5

Asphalt Binder

Option:	Superpave binder grading
A	9.5140 (correlated)
VTS:	-3.1280 (correlated)

High temp. °C	Low temperature, °C						
	-10	-16	-22	-28	-34	-40	-46
46							
52							
58							
64							
70							
76							
82							

Thermal Cracking Properties

Average Tensile Strength at 14ºF:	451.87
Mixture VMA (%)	12.3
Aggreagate coeff. thermal contraction (in./in.)	0.000005
Mix coeff. thermal contraction (in./in./ºF):	0.000013

Load Time (sec)	Low Temp. -4ºF (1/psi)	Mid. Temp. 14ºF (1/psi)	High Temp. 32ºF (1/psi)
1	3.28E-07	4.15E-07	5.26E-07
2	3.48E-07	4.68E-07	6.35E-07
5	3.76E-07	5.5E-07	8.15E-07
10	3.99E-07	6.2E-07	9.85E-07
20	4.24E-07	7E-07	1.19E-06
50	4.59E-07	8.22E-07	1.53E-06
100	4.87E-07	9.28E-07	1.84E-06

Layer 2 -- Asphalt concrete (existing)

Material type:	Asphalt concrete (existing)
Layer thickness (in):	9.2

General Properties

General

Reference temperature (F°):	70

Volumetric Properties as Built

Effective binder content (%):	9.3
Air voids (%):	2.5
Total unit weight (pcf):	148

Poisson's ratio:	0.35 (user entered)

Thermal Properties

Thermal conductivity asphalt (BTU/hr-ft-F°):	0.67
Heat capacity asphalt (BTU/lb-F°):	0.23

Asphalt Mix

Cumulative % Retained 3/4 inch sieve:	20
Cumulative % Retained 3/8 inch sieve:	33
Cumulative % Retained #4 sieve:	43
% Passing #200 sieve:	6

Asphalt Binder

Option:	Conventional viscosity grade
Viscosity Grade	AC 20
A	10.7709 (correlated)
VTS:	-3.6017 (correlated)

Layer 3 -- Crushed stone

Unbound Material: Crushed stone
Thickness(in): 14.6

Strength Properties

Input Level: Level 3
Analysis Type: Representative value (User Input Modulus)
Poisson's ratio: 0.35
Coefficient of lateral pressure,Ko: 0.5
Modulus (input) (psi): 30000
Moisture Content(%): -9999

ICM Inputs

Gradation and Plasticity Index

Plasticity Index, PI: 1
Liquid Limit (LL) 6
Compacted Layer Yes
Passing #200 sieve (%): 8.7
Passing #40 20
Passing #4 sieve (%): 44.7
D10(mm) 0.1035
D20(mm) 0.425
D30(mm) 1.306
D60(mm) 10.82
D90(mm) 46.19

Sieve	Percent Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8"	57.2
1/2"	63.1
3/4"	72.7
1"	78.8
1 1/2"	85.8
2"	91.6
2 1/2"	
3"	
3 1/2"	97.6
4"	97.6

Calculated/Derived Parameters

Maximum dry unit weight (pcf): 127.7 (derived)
Specific gravity of solids, Gs: 2.70 (derived)
Saturated hydraulic conductivity (ft/hr): 0.05054 (derived)
Optimum gravimetric water content (%): 7.4 (derived)
Calculated degree of saturation (%): 62.2 (calculated)

Soil water characteristic curve parameters: Default values

Parameters	Value
a	7.2555
b	1.3328
c	0.82422
Hr.	117.4

Layer 4 -- Crushed gravel

Unbound Material:	Crushed gravel
Thickness(in):	8

Strength Properties

Input Level:	Level 3
Analysis Type:	Representative value (User Input Modulus)
Poisson's ratio:	0.35
Coefficient of lateral pressure,Ko:	0.5
Modulus (input) (psi):	25000
Moisture Content(%):	-9999

ICM Inputs

Gradation and Plasticity Index

Plasticity Index, PI:	1
Liquid Limit (LL)	6
Compacted Layer	Yes
Passing #200 sieve (%):	8.7
Passing #40	20
Passing #4 sieve (%):	44.7
D10(mm)	0.1035
D20(mm)	0.425
D30(mm)	1.306
D60(mm)	10.82
D90(mm)	46.19

Sieve	Percent Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8"	57.2
1/2"	63.1
3/4"	72.7
1"	78.8
1 1/2"	85.8
2"	91.6
2 1/2"	
3"	
3 1/2"	97.6
4"	97.6

Calculated/Derived Parameters

Maximum dry unit weight (pcf):	127.7 (derived)
Specific gravity of solids, Gs:	2.70 (derived)
Saturated hydraulic conductivity (ft/hr):	0.05054 (derived)
Optimum gravimetric water content (%):	7.4 (derived)
Calculated degree of saturation (%):	62.2 (calculated)
Soil water characteristic curve parameters:	Default values

Parameters	Value
a	7.2555
b	1.3328
c	0.82422
Hr.	117.4

Layer 4 -- Crushed gravel

Unbound Material:	Crushed gravel
Thickness(in):	8

Strength Properties

Input Level:	Level 3
Analysis Type:	Representative value (User Input Modulus)
Poisson's ratio:	0.35
Coefficient of lateral pressure,Ko:	0.5
Modulus (input) (psi):	25000
Moisture Content(%):	-9999

ICM Inputs

Gradation and Plasticity Index

Plasticity Index, PI:	1
Liquid Limit (LL)	6
Compacted Layer	Yes
Passing #200 sieve (%):	8.7
Passing #40	20
Passing #4 sieve (%):	44.7
D10(mm)	0.1035
D20(mm)	0.425
D30(mm)	1.306
D60(mm)	10.82
D90(mm)	46.19

Sieve	Percent Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8"	57.2
1/2"	63.1
3/4"	72.7
1"	78.8
1 1/2"	85.8
2"	91.6
2 1/2"	
3"	
3 1/2"	97.6
4"	97.6

Calculated/Derived Parameters

Maximum dry unit weight (pcf):	127.7 (derived)
Specific gravity of solids, Gs:	2.70 (derived)
Saturated hydraulic conductivity (ft/hr):	0.05054 (derived)
Optimum gravimetric water content (%):	7.4 (derived)
Calculated degree of saturation (%):	62.2 (calculated)
Soil water characteristic curve parameters:	Default values

Parameters	Value
a	7.2555
b	1.3328
c	0.82422
Hr.	117.4

Distress Model Calibration Settings - Flexible

AC Fatigue	Level 4 (Regionally calibrated values)
k1	0.007566
Bf1	1
k2	3.9492
Bf2	1
k3	1.281
Bf3	1
AC Reflective Cracking	
c	1
	1
AC Rutting	Level 4 (Regionally calibrated values)
k1	-3.35412
Br1	1.5
k2	1.5606
Br2	1
k3	0.4791
Br3	1.15
Standard Deviation Total Rutting (RUT):	0.24*POWER(RUT,0.8026)+0.001
Thermal Fracture	Level 4 (Regionally calibrated values)
k1	1.5
Bt1	1
Std. Dev. (THERMAL):	0.1468 * THERMAL + 65.027
CSM Fatigue	Level 3: NCHRP 1-37A coefficients (nationally calibrated values)
k1	1
k2	1
Subgrade Rutting	Level 4 (Regionally calibrated values)
Granular:	
k1	2.03
Bs1	0.75
Fine-grain:	
k1	1.35
Bs1	0.75
AC Cracking	
AC Top Down Cracking	
C1 (top)	7
C2 (top)	3.5
C3 (top)	0
C4 (top)	1000
Standard Deviation (TOP)	200 + 2300/(1+exp(1.072-2.1654*log(TOP+0.0001)))
AC Bottom Up Cracking	
C1 (bottom)	1
C2 (bottom)	1
C3 (bottom)	0
C4 (bottom)	6000
Standard Deviation (TOP)	1.13+13/(1+exp(7.57-15.5*log(BOTTOM+0.0001)))
CSM Cracking	
C1 (CSM)	1
C2 (CSM)	1
C3 (CSM)	0
C4 (CSM)	1000
Standard Deviation (CSM)	CTB*11
IRI	
IRI HMA Pavements New	
C1(HMA)	40
C2(HMA)	0.4
C3(HMA)	0.008
C4(HMA)	0.015
IRI HMA/PCC Pavements	
C1(HMA/PCC)	0
C2(HMA/PCC)	0
C3(HMA/PCC)	0
C4(HMA/PCC)	0

APPENDIX D

FIELD ACTIVITES
PHOTOGRAPHS

Photograph 1: Replicate core location marked in field for drilling

Photograph 2: Driller centered for coring

Photograph 3: Core obtained using table mount driller

Photograph 4: 12 inch diameter bulk cores for lab testing

Photograph 5: FWD measurement at field

Photograph 6: Manual Distress Survey with video recording at field

Photograph 7: Obtaining trenches for rut measurement at field

Photograph 8: Rut depth measurement at field