TECHNICAL REPORT STANDARD PAGE

1. Report No. 363	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Evaluation of Louisiana's Maintenance Chip Seal and Micro-Surfacing Program	5. Report Date July 2002 6. Performing Organization Code	
7. Author(s) Erat S. Joseph and Shashikant C. Shah	8. Performing Organization Report No. 363	
9. Performing Organization Name and Address Southern University and Agricultural & Mechanical College Department of Civil Engineering Baton Rouge, LA 70813	10. Work Unit No. 11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Louisiana Transportation Research Center 4101 Gourrier Avenue Baton Rouge, LA 70808	13. Type of Report and Period Covered Final report January 1997 - July 2002 14. Sponsoring Agency Code	
15. Supplementary Notes		

16. Abstract

This report focuses valuation of Louisiana DOTD's chip seal and micro-surfacing treatments. The report discusses the performance in terms of Pavement Condition Index (PCI) of 40 chip seal and 24 micro-surface projects after approximately 52 months of service throughout the state. The evaluation is based on three separate subjective visual distress surveys and ARAN measured distress on cracking, roughness, and rutting. Sections vary in age from 41 months to 63 months.

The analysis indicated that the median PCI (Pavement Condition Index) of chip seal and micro-surface sections is about 75 and 85, respectively, after about 52 to 60 months of service. Based on the last PCI, about 70 percent of the chip seals were in good condition. Likewise, most of the micro-surface sections are in good to excellent condition.

The effect of pavement condition on PCI, prior to treatment application, was not evident from the distress data measured by ARAN equipment.

Chip seal sections showed bleeding in 70 percent of the sections. This bleeding was due to combination of factors relative to loss of aggregate, additional embedment and/or excess asphalt. However, most skid numbers are still in the safe range. The friction numbers on micro-surface sections have deteriorated considerably mainly due to the type of aggregates used in the mix.

Continued survey to end of service life of these sections is recommended to determine their service life and cost-effectiveness.

17. Key Words preventive maintenance; chip seal; surface treatment; micro-surfacing		18. Distribution Statement **Unrestricted. This document is available through the National Technical Information Service, Springfield, VA 21161.**	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

EVALUATION OF LOUISIANA'S MAINTENANCE CHIP SEAL AND MICRO-SURFACING PROGRAM

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LTRC NO. 97-6B
STATE PROJECT NO. 736-99-0457

Conducted for

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
LOUISIANA TRANSPORTATION RESEARCH CENTER

July 2002

ABSTRACT

This report focuses on evaluation of Louisiana DOTD's chip seal and micro-surfacing treatments. The report discusses the performance in terms of Pavement Condition Index (PCI) of 40 chip seal and 24 micro-surface projects after approximately 52 months of service throughout the state. The evaluation is based on three separate subjective visual distress surveys and ARAN measured distress on cracking, roughness, and rutting. Sections vary in age from 41 months to 63 months.

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ACKNOWLEDGMENTS

The authors would like to recognize the assistance of the Louisiana Department of Transportation and Development (DOTD) for funding of this study.

The cooperation of the nine districts in identifying preventive maintenance projects is acknowledged. Mr. William Temple, Chief Engineer, provided valuable guidance and assistance during the field survey of sections. His overall involvement in this study is appreciated.

The authors would also like to thank the management of the DOTD Information Technology Division for use of the SAS software system. Mr. Barry Nichols provided valuable guidance in the development of the various files for SAS analysis. Ms. Susan Nichols' effort in extracting data on maintenance cost is likewise appreciated.

The authors also wish to express appreciation to the Management System Division for their assistance in PMS data retrieval. The general guidance from LTRC is, likewise, acknowledged and appreciated.

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1. INTRODUCTION

All pavements start to wear soon after construction ends. This wear and tear is a result of changes in temperature, moisture content, and traffic. Small movements in underlying layers also contribute to minor defects that go unnoticed. Such minor defects, if not repaired in a timely fashion, can lead to more serious problems that can only be corrected through rehabilitation or reconstruction of the pavement which are both high cost alternatives.

In order to preserve the pavement above the minimum acceptable level, timely maintenance is the only alternative. Timely maintenance is a form of preventive maintenance. More and more agencies, including Louisiana, are becoming aware of this alternative by expanding their program of preventive maintenance before "demand" maintenance becomes necessary. Preventive maintenance procedures are routine or major actions preventing pavement condition from deteriorating to a "higher" level of rehabilitation.

Although Louisiana has instituted such a preventive maintenance program through the application of chip seals and micro-surfacing on candidate pavements, there is a lack of qualitative data on the most effective treatment for a given pavement condition, resulting in least cost. Thus, the DOTD Division of Maintenance requested a study to provide guidelines and information needed to determine the cost-effectiveness of the program (in preserving pavement life) and to ensure optimum use of available maintenance funds.

This report discusses the results of the various tasks in the work plan. These tasks are defined in the next section under Objectives and Scope.

2. OBJECTIVES ,SCOPE AND WORK PLAN

A. Objectives

The major objective of this study is to evaluate the effectiveness of DOTD's chip seal and micro-surfacing program for equitable allocations of funds in its overall preventive maintenance program. Specific study objectives are:

1. To identify projects that have received preventive maintenance over the last three fiscal years;
2. To define critical influencing factors (that effect performance) and the performance parameters to evaluate projects identified in objective 1;
3. To define data elements and develop a database to evaluate the effectiveness of the preventive treatments; and
4. To evaluate the effectiveness of the program from a performance and cost perspective.

B. Scope

In scope, the study will:

- analyze data collected over a three-year period;
- be limited to 40 chip seal and 24 micro-surface projects;
- be limited to evaluation of performance relative to age and traffic factors and not factors associated with materials and/or construction.

C. Work Plan

The four objectives are to be accomplished through seven distinct tasks as follows:

Task 1. Identify and locate chip seal and micro-surfacing projects for evaluation from DOTD's files and/or site visits

Task 2. Review literature pertinent to study objectives

Task 3.	Develop a database and experimental plan to evaluate the effectiveness of the preventive maintenance program
Task 4.	Submit interim report on the results of the first three tasks.
Task 5 & 6.	Implement Task 3 to develop, evaluate, and modify cost-effectiveness model
Task 7.	Submit a final report documenting findings of all six tasks.

The accomplishments of the first three tasks were discussed in the interim report of September 1997 (1)* and, therefore, will not be discussed again in this report. In the following sections, discussion is confined to the analysis and evaluation phase of the study only. However, findings discussed in the interim report will be summarized whenever deemed appropriate.

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* - Underlined numbers in parentheses refer to list of references

SUMMARY OF LITERATURE REVIEW

Several references were reviewed relative to what and when of preventive maintenance with major emphasis on the SHRP project H-101 (2,3). Findings from the SHRP study and various other literature reviews reported in the interim report (1) indicated:

- that routine maintenance does have an impact on roughness;
- that climate, age and thickness of the slab are important main factors affecting performance;
- that various maintenance activities have an effect on each other;
- that the average long term annual cost is much higher when the pavement is allowed to deteriorate; and
- that the most cost-effective maintenance strategy depends on both pavement condition and traffic; and
- that the average life of chip seal is 4-6 years and that of micro-surfacing 4-7 years.

4. IDENTIFICATION OF PROJECTS AND DATA ELEMENTS

This chapter deals with the background information on preventive maintenance information followed by sources of information that were used to identify completed chip seal and micro-surfacing projects in the state and the various data elements from which the database was developed for evaluation.

Background on Preventive Maintenance -

The two types of pavement maintenance generally used are preventive and corrective. The former is recognized as more cost-effective than the latter since it prevents progressive deterioration by taking timely (maintenance) measures to arrest minor deterioration and reduce the risk of corrective maintenance, which is generally performed at a stage when the pavement has reached extensive deterioration. Two major questions need to be answered before any action can be taken. One is "what" type of treatment should be applied and, the other, "when" (which relates to timing) it should be applied.

There are a number of preventive maintenance treatments for flexible and composite pavements that can provide answers to "what" should be used. The answers also rest on the type of distress or distresses that need to be taken care of for the treatment to be effective. For example, of the following treatments, crack sealing is effective when low to moderate cracks of the fatigue, longitudinal, and/or transverse type is encountered. Micro-surface is highly effective as a rut filler and minor leveling but not very effective for medium to high severity cracking. Along the same lines, chip seals are ineffective as rut (>3/8") fillers but quite effective as crack sealers (water proofing). Such guidelines for effective maintenance treatments have been defined by engineers involved in the evaluation of SHRP SP-3 and 4 test sections in the southern region of the United States (*4*). Preventive maintenance treatments usually considered are:

- Crack Seal
- Slurry Seal
- Fog Seal
- Chip Seal
- Micro-surfacing
- Thin Hot-Mix Overlay

The answer to "when" is depicted in Figure 4.1. An important aspect of "when" lies in the identification of a range of trigger values on either a single performance parameter such as roughness or skid numbers or an index of several performance parameters such as PCI or Pavement Condition Index within which preventive maintenance may be beneficial. There is a practical range above and below which preventive maintenance may be ineffective and even uneconomical.

Louisiana's preventive maintenance program involves the use of chip seal and micro-surfacing. Most of the chip seal projects investigated in this study are low volume roads (1000-2000 ADT) and consist of a single layer of aggregate ranging in thickness from 1/2 inch to 3/4 inch. The predominant aggregate material has been expanded clay lightweight and, in some instances, crushed stone or crushed gravel. As mentioned above, waterproofing the pavement was the primary reason for application of this type of surface seal.

The micro-surfacing projects in Louisiana have been applied to level longitudinal rutting and restore friction characteristics. As such, it has been applied on heavy volume roads including interstate systems (25,000+ ADT). Microsurfacing consists of polymer-modified emulsified asphalt cement, well graded crushed mineral aggregate, mineral filler, and water.

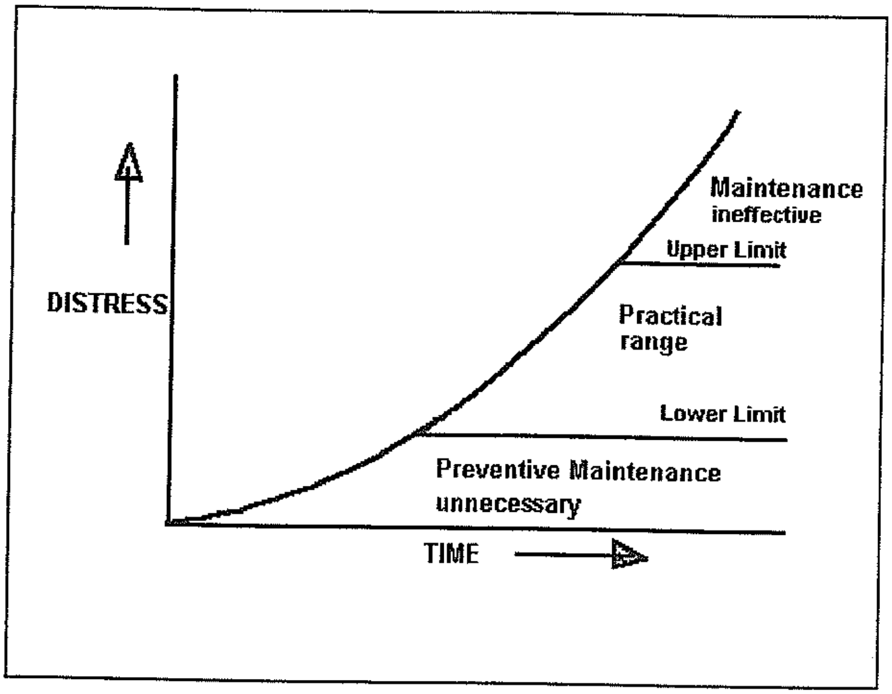


Figure 4.1: Effectiveness of maintenance operations

Identification of Preventive Maintenance Projects -

A preliminary list of projects that had received either chip seal or micro-surfacing was prepared using the department's tracking of projects (TOPS) file. This file contains information relative to: project number, location, length, bid date, completion date, final cost, etc.

The above list was then sent to each of the nine districts to confirm the information collected from the TOPS file. Table 4.1 shows the number of projects by the type of preventive maintenance in each district. Figure 4.2 is a map showing the general location of the selected preventive maintenance projects.

Table 4.1: List of preventive maintenance projects

District	No of Projects	Improvement	
		MS(*)	CS(*)
02	7	7	0
03	7	2	5
04	5	1	4
05	6	5(4) a/	2
07	12	2	10
08	5	2	3
58	9	2	7
61	6	1	5
62	7	3	4
Total	64	24	40

(*) - MS=Micro-surface, CS=Chip seal

a/ - two MS projects combined into one

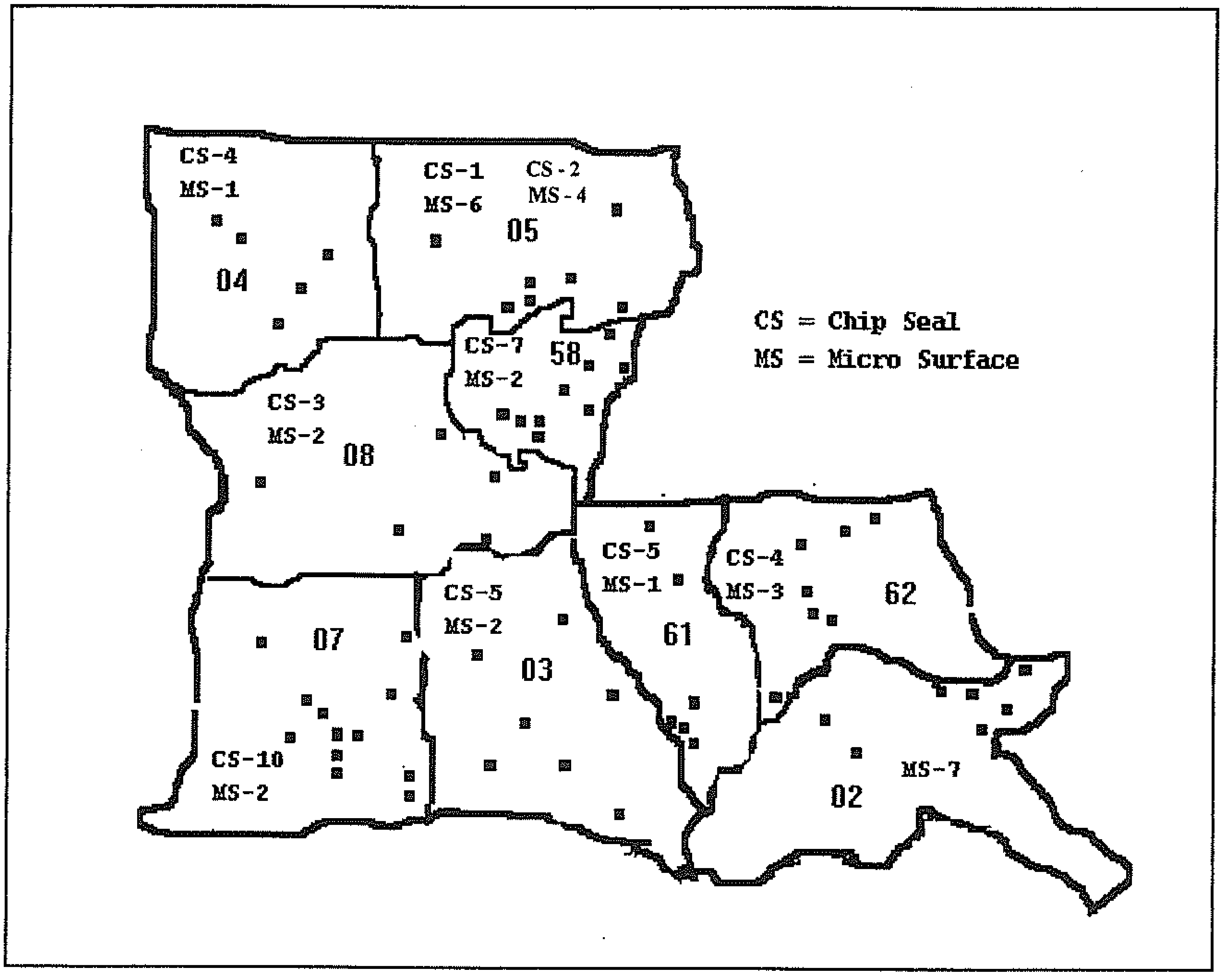


Figure 4.2
General location of preventive maintenance projects

Project Data Needs

The data collected for this study were divided into field information and historical information. The field data were obtained from surveys and measurements on each project while the historical data were extracted from agency records (e.g., traffic, materials, climate, construction). Historical data generally fall short of the requirements for designed studies since they are either missing information or lack accuracy.

Data considered necessary for evaluation of treatment effectiveness were grouped into three broad categories as follows:

1. Inventory/Historical Data
2. Pavement Condition Data

3. Cost Data

Specific data elements within each of the above categories are defined below.

1. **Inventory/Historical Data**
   - Project identification information
   - Pavement type
   - Pavement geometrics
   - Age
   - Pavement cross section
   - Climate
   - Traffic (ADT)

2. **Pavement Condition Data**
   - Surface distress
   - Roughness
   - Surface friction

3. **Cost Data**
   - Cost of improvement
   - Routine maintenance cost

Data Source

The database, containing the data elements defined above, was developed from the various DOTD files. Brief discussion of these files follow. Some data elements appear in more than one file.

Inventory/Historical Data Files -

TOPS - Tracking of Projects: As the name suggests, this file contains information on the status of the construction project from the letting stage through completion and the final cost estimate. Contract information relative to location, length, highway class, highway number, etc., is also contained in this file. As aforementioned, this file was the trigger file for the preliminary selection of projects for this study.

TAND - Highway Needs and Priorities: This file is the department's most comprehensive file for the development of a yearly highway construction program at the network level. It contains information relative to segment identification, existing geometrics, traffic, structural cross section, pavement roughness, friction number, existing deficiencies, improvement needed and associated cost, etc., on each homogeneous segment of the roadway.

TATV - Traffic Count (ADT): This file contains detailed data on yearly traffic patterns.

Pavement Distress Data Files

PMS - Pavement Management System: This is the most comprehensive file containing data on the condition of DOTD's network system. In some respects, it complements the TAND file. The PMS file is generated from the information collected using a high speed pavement condition survey vehicle, ARAN, and consultant developed software. This network survey is conducted once every two years through contract. The ARAN generates two types of data: measured data and interpreted data. Measured data includes roughness, rutting, faulting in concrete pavement, and thickness of the pavement as measured by GPR. Interpreted data is generated from videos of each pavement segment in terms of cracking and patching. All data, measured and interpreted, is generated every tenth of a mile. Table 4.2 lists the various distresses on which data is available in this file.

Of the distresses defined in table 4.2, data on the following were included in the data bank:

- GPR thickness
- Roughness (IRI)
- Rutting
- Alligator cracking
- Random cracking

Table 4.2: PMS distress file documentation

DISTRESS ID	DESCRIPTION	UNIT OF MEASUREMENT
CTL_SECT	Control Section Identification	N/A
CS_FROM	Beginning of Control Section Log Mile	N/A
CS_TO	End of Control Section Log Mile	N/A
PAVETYPE	Type of Pavement (ASP=asphalt, COM=Composite, etc.	N/A
RL_AVG	Average Rutting in Left wheel path	Inches
RL_STD	Standard Deviation of Rutting in Left wheel path	"
RR_AVG	Average Rutting in Right wheel path	"
RR_STD	Standard Deviation of Rutting in Right wheel path	"
R_AVG	Average Rutting of Right and Left wheel paths	"
R_STD	Average of Left & Right Rutting Standard Deviation	"
L_IRI	International Roughness Index - Left	N/A
R_IRI	International Roughness Index - Right	N/A
AVF_IRI	Average IRI - Left and Right	N/A
ALGCRK_L	Low severity Alligator Cracking	Square Feet
ALGCRK_M	Medium severity Alligator Cracking	"
ALGCRK_H	High severity Alligator Cracking	"
LNGCRK_L	Low severity Longitudinal Cracking	Linear Feet
LNGCRK_M	Medium severity Longitudinal Cracking	"
LNGCRK_H	High severity Longitudinal Cracking	"
TRNCRK_L	Low severity Transverse Cracking	Linear Feet
TRNCRK_M	Medium severity Transverse Cracking	"
TRNCRK_H	High severity Transverse Cracking	"
PATCH_L	Low severity Patching	Square Feet
PATCH_M	Medium severity Patching	"
PATCH_H	High severity Patching	"
N_PATCH_L	Number of Low Patches	N/A
N_PATCH_M	Number of Medium Patches	N/A
N_PATCH_H	Number of High Patches	N/A

Table 4.2(cont'd): PMS distress file documentation

DISTRESS ID	DESCRIPTION	UNIT OF MEASUREMENT
BLKCRK_L	Low severity Block Cracking	Square Feet
BLKCRK_M	Medium severity Cracking	"
BLKCRK_H	High severity Cracking	"
PUMPING	Number of occurrences per subsection	N/A
N_POTHOLE	Number of Potholes	N/A
A_POTHOLE	Area of Potholes	Square Feet
RAVELING	Presence of Raveling	N/A
N_DE_LAM	Presence of Delamination	"
GPR_THIC	Ground Penetrating Radar Pavement Thickness	Inches
GPR_STD	GPR Thickness Standard Deviation	Inches
ALCR	Alligator Cracking Index (Scale 1-100, 100 being perfect)	N/A
RNDM	Random Cracking Index (Scale 1-100, 100 being perfect)	"
PTCH	Patching Index (Scale 1-100, 100 being perfect)	"
RUT	Rutting Index (Scale 1-100, 100 being perfect)	"
RUFF	Roughness Index (Scale 1-100, 100 being perfect)	"
TRAN	Transverse Cracking Index (Scale 1-100, 100 being perfect)	"
LONG	Longitudinal Cracking Index (Scale of 1-100, 100 being perfect)	"
POT_PATCH	Area per subsection of Patching and Medium Patches	Square Feet
RND_L	Low severity Random Cracking	Linear Feet
RND_M	Medium severity Random Cracking	"
RND_H	High severity Random Cracking	"
COMP	Composite Index	N/A

Cost Data Files

TOPS - Tracking of Projects: This file contains data on the final cost of the project. Maintenance cost files did not provide any information on the maintenance cost of these sections.

Pavement Condition Index (PCI) File

This file consists of data collected using subjective judgment of various distresses. This collection procedure is discussed in detail in the next chapter.

Data Availability

Not all data that are needed to develop databases were readily available in the study. This is particularly true of the PMS File. As noted before, the data is collected once every two years with the first collection in fiscal year 1994-1995. The second set of data collection was completed during 1997 and 1998.

An important aspect of the effectiveness analysis is the availability of surface condition (distress) prior to construction of preventive maintenance treatments. It has been reasonably established from previous studies *(4)* that the condition of the pavement prior to seal coat application has a marked effect on the life of the seal coat. The first set of ARAN survey data (95-96) was used as preconstruction pavement condition data, since a majority of the projects selected were constructed in late 1995 and/or early 1996 prior to the ARAN surveys.

Data Quality

Data availability does not always guaranty data quality as was determined from scanning the data in some of the files discussed above. Problems encountered were absence of friction number, wrong codes for surface type, too broad a classification of structural numbers, no thickness data in the MATT system cross section files, etc. Such deficiencies are discussed in detail in reference (1).

Database Development

All of the above data from various files were combined into two separate databases, one for chip seal and the other for micro-surface. Each record in the database consists of information on the categories (inventory, ARAN distress, Pavement Condition Index (PCI), cost) discussed in the preceding sections. Information on each project is a record. The files are SAS *(5)* data files.

5. DATA COLLECTION AND SAMPLING PLAN

Study Data Collection & Sampling Plan

Because of lack of sufficient (periodic) data available in the PMS files, an in-house collection plan was designed for a field survey of preventive maintenance study. The plan was designed to conduct a field survey by visual inspection of the sections*(6, 7)*. Figure 5.1 is the form that was used for this survey.

The survey involved identifying types of road surface distress characteristics in terms of the *severity* and *extent* of that distress. The severity of the distress characteristic can be measured (e.g., rutting) or estimated visually and then the extent of the severity within a section of road can be assessed.

The term severity applies to the degree of deterioration of the various types of distress that are described on the condition survey sheet. The term extent refers to the frequency of occurrence or amount of road surface showing the particular distress.

Preparation for performing a condition survey required establishing a travel plan to efficiently survey the projects in each district such that travel time was minimized between projects. The survey was completed by a party of two. It was a walking survey of a randomly selected 500 to 700-foot section. This section (for survey) was selected by first traveling the entire project and then randomly selecting a section that could be identified to some permanent benchmark for future periodic evaluation. The section was also marked with colored paint. Each section required between 30 and 40 minutes for the completion of the survey. The visual condition survey was recorded on forms similar to the one shown in Figure 5.1. This visual condition survey was reinforced with photographs of the sections. Four separate condition surveys were conducted during the study period. Photographs of project study sections, showing poor and good level of performance (based on low PCI and high PCI as explained later), are shown in Appendices C and D for chip seal and micro-surface sections, respectively.

Whenever possible, ruts were measured with an AASHTO-type A-frame device. Data were also obtained on friction numbers and roughness measured as International Roughness Index

(IRI). However, only one set of data was collected for these parameters, which coincided with the last set of condition surveys.

PAVEMENT CONDITION RATING FORM

Project No: **018-01-0026** **District:** **02** **Name:** **Jct US 90 - S End L Ponchart Br**

Project Begin: **Jct US 90**

Project End: **South End of Lake Ponchartrain Bridge**

Route: **US 11** **Seal Type: Microsurface** **Project Length: 5.86**

Date Constructed: **12/95** **Date Surveyed:** ________ **Surveyed By:** ______________

Test Section Begin:____

Test Section End: ______________________________ **Insp Lane: NB SB EB WB**

Distress		Severity Level				Extent Level				Deduct
Type	Weight Factor	None	Low	Med	High	None	Occ	Freq	Ext	Points
Long/Trans Cracking	20	None 0.1	< 1/4 0.2	1/4 0.6	> 1/4 1.0	None 0.1	< 10%L 0.4	10-30 0.58	> 30% L 1.0	
Alligator Cracking	15	None 0.1	< 1/8 " 0.2	1/8" 0.6	> 1/8" 1.0	None 0.1	< 10%A 0.4	10-30 0.8	> 30% A 1.0	
Edge Cracking	10	None 0.1	< 1' 0.2	1-2' 0.6	> 2' 1.0	None 0.1	< 10% 0.4	10-30 0.8	> 30% 1.0	
Patch/Pothole	10	None 0.1	Small 0.6	Med 0.8	Large 1.0	None 0.1	< 5/1K' 0.6	5-10 0.8	> 10 1.0	
Rutting	10	< 1/4" 0.1	1/4-1/2 0.3	1/2-1" 0.7	> 1" 1.0					
Aggregate Loss	10	None 0.1	Slight 0.3	Mod 0.8	Severe 1.0	None 0.1	< 10%A 0.5	10-30 0.8	> 30% A 1.0	
Bleeding	10	None 0.1	Slight 0.6	Mod 0.8	Severe 1.0	None 0.1	< 10%A 0.6	10-30 0.8	> 30% A 1.0	
Roughness	15		Good 0.2	Fair 0.6	Poor 1.0					

Deduct Points = (Distress Weight Factor) x (Severity Weight Factor x Extent Weight Factor)

Total Deduct Points (TDP) =

Pavement Condition Rating, PCI = (100 - TDP)

Figure 5.1: Pavement condition rating form

The deduct points (figure 5.1) for a given distress type were derived by multiplying the weight factors for the distress type, severity, and extent. Then the deduct points for each distress type were added to yield the total deduct points.. The final pavement condition rating was obtained by subtracting the total deduct points from 100 and is expressed as *Pavement Condition Index* or *PCI.* This index is basically a ranking tool. Although there is no consensus in the highway community on the standard PCI, it ranks the inspected pavement from bad to good (0 to 100) and allows the user to communicate the relative condition within and between different sections for a given time period. A scale such as the one in figure 5.2 can be used to rate the pavement for maintenance and rehabilitation needs *(8)*. Data collected from the four distress surveys are shown as tables in *Appendices A and B.*

PMS Data Collection & Sampling Plan

As mentioned before, two sets of ARAN survey data were available from the PMS file. The first set represents data from the 1994-1995 survey of the network system and the second set represents a 1997-1998 survey. The former forms the basis for defining preconstruction condition of the study sections.

PCI		Rating
86-100		Excellent
71-85		V. Good
56-70		Good
41-55		Fair
26-40		Poor
11-25		V. Poor
0-10		Failed

Figure 5.2: PCI scale

6. DATA ANALYSIS

The objective of this study is to determine the impact of the preventive maintenance treatments, with chip seal and micro-surface on preserving and extending pavement service life and the benefits they provide in terms of cost of these treatments. Since performance is dependent on several factors, it is necessary to define these factors and the different levels (or boundaries) that may have impact on performance.

Influencing Factors

Influencing factors are those that are judged to have some effect on pavement performance either singularly or in combination. These influencing factors are the X variables in the experiment. Based on the previous discussion on data needs and data availability, and the findings of earlier studies (*1*), the following factors (not necessarily in order of importance) are considered to have impact on the performance of preventive maintenance: [Although factors relative to construction, materials, and preconstruction preparation of the pavement do have effect on the performance, it is outside the scope of this study to determine their effect on performance]. A brief discussion of each factor is provided below. The data on some of these factors appear in various tables in the next two chapters.

1. Pavement type (asphalt, composite)
2. Existing pavement condition (good, fair, poor)
3. Total pavement thickness
4. Location (north, south)
5. Traffic (high, low)
6. Age since construction

1. Pavement Type

Different materials have different engineering behavior and characteristics. The type of performance profile to expect depends on whether the pavement is flexible, rigid or composite. In this study, two types of pavements are included, *flexible* and *composite*.

2. Pavement Condition

Results of a previous study *(4)* have shown that the condition of the pavement at the time of treatment application and the structural capacity of the pavement have the most influence on the treatment performance. The underlining purpose of preventive maintenance treatment is to retard the rate of pavement deterioration. This can be effectively achieved if the treatment is applied on a pavement that is in fair or good condition rather than one in poor condition. There is a condition level at or below which the preventive treatments will have little effect in terms of cost effectiveness (see figure 3.1). Three levels are defined to study the effect of this factor - *good, fair* and *poor*.

3. Pavement Thickness

The structural capacity of the pavement is directly related to its thickness and material properties. Thinner pavements are more susceptible to cracking by fatigue. Therefore, under certain loading conditions, thickness or structural number is a good indicator of the cracking potential. In this analysis, thickness will be used as the parameter due to a lack of adequate data on structural number. The values for this factor are the GPR (Ground Penetrating Radar) values from ARAN.

4. Location

This variable is included to study the differences in performance attributable to climate. Northern areas of the state experience a greater number of below-freeze days than southern parts of the state. Louisiana has nine districts, four of which are in the northern part of the state and five of which are in the southern part. Therefore, the analysis will be performed at two levels - *north* and *south*, as is shown on the map in figure 4.1, in chapter 4.

5. Traffic

This factor will be evaluated in terms of ADT. Two levels, ***high*** (>1000) and ***low (≤ 1000)***, will be considered.

6. Age

This factor is the period between the construction date of the chip seal and micro-surfacing projects and the condition evaluation date. These dates are shown in the Appendix A and B. The ARAN survey age (since construction) is listed as AGE1 and AGE2, and the condition survey age is listed as AGE3, AGE4, AGE5, and AGE6 in the tables in chapters 7 and 8. The negative values under AGE1 represent preconstruction age (ARAN survey date minus construction date).

Dependent Factors

Dependent factors are the Y-axis variables in the experiment. Pavement performance can be assessed in terms of three basic indicators: *pavement distress, pavement roughness or safety*.

The first indicator, *pavement distress* will be in terms of Pavement Condition Index (PCI) as was previously discussed and showing in figure 5.1. All four PCI surveys are presented in the next two chapters.

The second indicator, *Roughness*, is the International Roughness Index (IRI). The units of IRI are actually dimensionless since it is a slope statistic, but it has been scaled by a factor of 1,000 so that it represents m/km or inches/1,000 inches. Skid resistance is the attribute of the pavement that contributes to *safety*.

The above dependent variables will be investigated in terms of the variable itself or rate of change in that variable.

The performance of the pavement can also be affected by the degree of uniformity of the project relative to traffic, structural design, pavement materials, and subgrade condition. No documentation exists to verify the uniformity or nonuniformity of the length of the projects selected for this study. Likewise, no information was available on the preconstruction preparation (crack sealing, patching, etc.) of the projects.

Performance Evaluation

As noted at the beginning of this section, the analysis is limited to the factors mentioned above and assumes that standard practices relative to materials and construction were followed as required by the governing specifications.

The various data generated by ARAN survey, DOTD survey, and subjective condition survey during the monitoring period are shown in the tables in the next two chapters. The evaluation that follows in the next two chapters has two objectives. The first is to determine the life expectancy of the pavement and second is to evaluate the effect of the preconstruction condition of the pavement (timing) on the treatment application.

7. PERFORMANCE OF CHIP SEALS

Effect of Treatment Age on Performance -

The four surveys for the study sections appear in table 7.1. They are labeled from Age3-PCI3 to AGE6-PCI6. Table 7.2 shows the individual distress deduct values (for the last survey) contributing to the final PCI. The data in table 7.1 for individual study sections are presented graphically in figures 7.1a through 7.1h. figure 7.2 is a bar chart of the average age at last evaluation and the corresponding PCI for the projects in each district. figure 7.3 is a frequency distribution of all PCI's regardless of age.

The flat trend of the curves in figure 7.1 indicates that most of the sections are still in a steady state of performance. The median statewide PCI is 75 after almost 52 months of service. Of the 40 projects, only two or five percent can be categorized in poor condition and seven or eighteen percent in fair condition according to the scale in figure 5.2. About 75 percent fall in the good to excellent condition category. District 3 has the most number of sections in the fair category. Likewise, most of the sections in this district have been in service the longest (over four years).

The actual pavement performance curves of figure 7.1a through 7.1h have been defined by the equation *(9)*:

$$\mathbf{PCI = 100 - bx^m}$$

where 'b' is the slope coefficient, 'x' is the pavement age in months, and 'm' is a parameter that controls the curvature of the curve.

As stated earlier, the average life of chip seals is in the four to six year range assuming proper design, materials, and construction procedures were followed. Based on the last condition evaluation, it is likely that most of the sections will provide satisfactory service to that time and beyond. However, since the actual pavement performance curve follows a logarithmic trend shown by the above equation, the sudden dip (downwards) tends to occur during the last few months of service. Sections that are presently in the fair category need to be evaluated more frequently to adequately define their end of life.

Of the 40 projects, two (one in District 61 and one in District 07) have been rehabilitated with a single lift hot mix overlay. The PCI for the project in District 61 was 42 after the second survey at 29 months. It is interesting to note that most of the projects with PCI in the 50-60 range as of the last survey also had a low PCI range in the first two years of service. Most of these projects had high deduct values (see tables 7.1 through 7.2 and Appendix A), which was in large part contributed by moderate to high severity longitudinal, transverse, and alligator cracking. Preparation generally contributes to this premature presence of reflection cracks. A project in District 4 had high severity longitudinal cracks reflected within 10 months after chip seal application. The point that is being made here is that surface preparation should be an integral part of the preventive maintenance program. Likewise, suitable projects should be selected for preventive maintenance to be cost-effective.

Further monitoring of these sections (to end of life) will provide an excellent data base for the determination of trigger values on individual distresses for future planning of the preventive maintenance program. For example, pavements indicating high severity cracking should become prime candidates for chip seal application although their PCI level may not be in the critical range for any such surface rehabilitation action. Such a case is observed in table 7.2, which shows several projects that have high deduct values due to high severity and extent of cracking yet their PCI levels are still in the "safe" range. In the last evaluation, the longitudinal and transverse cracking on some of these projects exceeded 50 percent of the area. It is felt that some of these projects may have passed the point (trigger value) for any preventive maintenance to be cost-effective.

Table 7.1: Pavement Condition Index data on chip seal projects

PAVEMENT CONDITION INDEX (PCI) DATA ON CHIP SEAL PROJECTS

DIST	PROJ_NO	RTE	LENG	ADT	AGE3	TDP3	PCI3	AGE4	TDP4	PCI4	AGE5	TDP5	PCI5	AGE6	TDP6	PCI6
3	235-01-0007	LA329	4.20	3272	27	32	68	40	39	61	52	45	55	63	53	47
3	393-03-0013	LA343	5.23	2254	27	43	57	40	47	53	52	50	50	63	50	50
3	385-04-0004	LA92	2.70	528	12	5	95	25	5	95	37	10	90	47	10	90
3	203-01-0007	LA29	4.14	2996	27	42	58	40	53	47	52	57	43	62	57	43
3	850-08-0008	LA352	2.64	1714	27	56	44	40	60	40	52	63	37	62	63	37
4	043-06-0020	LA9	7.49	2578	10	37	63	27	37	63	39	47	53	50	47	53
4	111-01-0016	LA531	7.92	518	10	5	95	27	5	95	39	8	92	50	8	92
4	085-03-0013	LA160	6.26	319	22	24	76	39	24	76	51	26	74	62	26	74
4	082-05-0006	LA157	7.22	867	8	11	89	25	11	89	37	12	88	48	18	82
5	166-05-0005	LA132	4.99	1066	21	20	80	38	31	69	50	31	69	61	31	69
5	037-02-0032	LA2	9.00	3637	20	28	72	37	38	62	49	40	60	60	40	60
7	199-01-0006	LA102	7.43	469	12	8	92	25	8	92	37	22	78	47	22	78
7	031-08-0017	LA27	11.72	3950	12	12	88	25	15	85	37	18	82	47	24	76
7	382-04-0033	LA384	5.66	1211	27	14	86	40	14	86	52	21	79	.	.	.
7	193-02-0041	LA27	5.45	3328	17	8	92	30	8	92	42	13	87	52	15	85
7	193-03-0008	LA27	2.13	2968	17	12	88	30	12	88	42	16	84	52	16	84
7	193-04-0008	LA27	6.24	1245	17	5	95	30	6	94	42	16	84	52	16	84
7	196-01-0019	LA14	7.27	3249	12	11	89	25	11	89	37	13	87	47	15	85
7	193-05-0015	LA14	4.97	3520	17	21	79	30	21	79	42	31	69	52	31	69
7	827-31-0003	LA3056	1.89	519	26	6	94	39	6	94	51	8	92	61	14	86
7	812-08-0003	LA3056	2.33	519	26	8	92	39	9	91	51	9	91	61	16	84
8	057-08-0012	US167	3.57	990	20	14	86	37	20	80	49	21	79	60	26	74
8	858-12-0001	LA489	2.80	248	.	.	.	20	8	92	32	16	84	43	16	84
8	365-01-0008	LA472	8.77	199	.	.	.	20	5	95	32	6	94	41	12	88
58	143-05-0021	LA124	5.48	628	.	.	.	19	19	81	31	19	81	42	25	75
58	143-06-0023	LA124	4.36	783	.	.	.	19	26	74	31	20	80	42	36	64
58	152-02-0008	LA8	2.29	1257	.	.	.	39	25	75	51	25	75	62	28	72
58	039-04-0043	LA8	3.83	2999	8	6	94	25	14	86	37	26	74	48	26	74
58	173-01-0025	LA4	4.65	609	.	.	.	19	9	91	31	11	89	42	11	89
58	036-04-0049	LA4	7.15	5928	8	5	95	25	8	92	37	8	92	48	24	76
58	051-03-0027	LA17	12.91	3360	22	10	90	39	12	88	51	18	82	62	18	82
61	863-02-0022	LA421	6.92	614	19	14	84	31	17	83	42	17	83	53	17	83
61	804-28-0008	LA1015	0.66	1178	17	14	86	29	20	80	41	27	73	55	27	73
61	804-29-0009	LA1015	0.76	972	17	15	85	29	28	72	41	28	72	55	34	66
61	804-38-0006	LA1016	3.85	1777	17	48	52	29	58	42	41	58	42	.	.	.
61	804-20-0003	LA999	1.29	418	17	24	76	29	46	54	41	46	54	55	48	52
62	858-09-0017	LA430	8.83	1242	8	26	74	20	26	74	32	30	70	42	30	70
62	278-05-0005	LA1061	4.56	827	8	25	75	20	32	68	32	28	72	42	28	72
62	260-09-0005	LA441	3.80	1028	25	40	60	37	47	53	49	45	55	59	45	55
62	260-06-0009	LA43	3.69	3154	25	20	80	37	22	78	49	22	78	59	24	76

Table 7.2: Individual distress deduct points for chip seal projects

INDIVIDUAL DISTRESS DEDUCT POINTS FOR CHIP SEAL PROJECTS

DIST	PROJ_NO	RTE	LENG	ADT	AGE6	LCRACK6	ACRACK6	ECRACK6	POTHOLE6	BLEED6	RUT6	AGGLOSS6	ROUGH6	PCI6
3	235-01-0007	LA329	4.20	3272	63	20.0	7.20	4.8	3.6	3.8	3	1.5	9	47
3	353-03-0013	LA343	5.23	2254	63	16.0	7.20	0.8	3.6	6.4	3	1.5	12	50
3	385-04-0004	LA92	2.70	528	47	1.6	0.15	0.1	0.1	3.6	1	1.5	3	90
3	203-01-0007	LA29	4.14	2996	62	20.0	15.00	4.8	0.1	3.6	1	0.1	12	43
3	850-08-0008	LA352	2.64	1714	62	20.0	15.00	4.8	3.6	3.6	7	0.1	9	37
4	043-06-0020	LA9	7.49	2578	50	20.0	1.20	0.8	10.0	3.6	1	1.5	9	53
4	111-01-0016	LA531	7.92	518	50	1.6	0.15	0.1	0.1	0.1	1	1.5	3	92
4	085-03-0013	LA160	6.26	319	62	12.0	1.20	0.8	0.1	0.1	1	1.5	9	74
4	082-05-0006	LA157	7.22	867	48	1.6	1.20	0.1	0.1	3.6	1	1.5	9	82
5	166-05-0005	LA132	4.99	1066	61	20.0	7.20	0.1	0.1	3.6	1	1.5	9	69
5	037-02-0032	LA2	9.00	3637	60	9.6	0.15	0.8	3.6	8.0	3	6.0	9	60
7	199-01-0006	LA102	7.43	469	47	12.0	0.15	0.1	0.1	3.6	1	1.5	3	78
7	031-08-0017	LA27	11.72	3950	47	4.8	0.15	0.1	0.1	6.4	1	2.4	9	76
7	382-04-0033	LA384	5.66	1211	.	.	.	.	.	.	.	.	.	.
7	193-02-0041	LA27	5.45	3328	52	3.2	0.15	0.1	0.1	3.6	3	1.5	3	85
7	193-03-0008	LA27	2.13	2968	52	1.6	0.15	0.1	0.1	6.4	3	1.5	3	84
7	193-04-0008	LA27	6.24	1245	52	4.2	0.15	0.1	0.1	3.6	3	1.5	3	84
7	196-01-0019	LA14	7.27	3249	47	3.2	0.15	0.1	0.1	3.6	3	1.5	3	85
7	193-05-0015	LA14	4.97	3520	52	16.0	0.15	0.1	0.1	3.6	3	4.8	3	69
7	827-31-0003	LA3056	1.89	519	61	1.6	0.15	0.1	0.1	0.1	1	1.5	9	86
7	812-08-0003	LA3056	2.33	519	61	3.2	0.15	0.1	0.1	0.1	1	0.1	9	84
8	057-08-0012	US167	3.57	990	60	12.0	0.15	0.1	0.1	0.1	1	0.1	9	74
8	858-12-0001	LA489	2.80	248	43	9.6	0.15	0.1	0.1	0.1	1	1.5	3	84
8	365-01-0008	LA472	8.77	199	41	1.6	0.15	0.1	0.1	0.1	1	0.1	3	88
58	143-05-0021	LA124	5.48	628	42	9.6	0.15	0.1	0.1	3.6	1	1.5	9	75
58	143-06-0023	LA124	4.36	783	42	20.0	1.20	0.1	0.1	3.6	1	1.5	9	64
58	152-02-0008	LA8	2.29	1257	62	20.0	0.15	0.1	0.1	0.1	1	0.1	6	72
58	039-04-0043	LA8	3.83	2999	48	16.0	0.15	0.1	0.1	3.6	1	1.5	3	74
58	173-01-0025	LA4	4.65	809	42	3.2	0.15	0.1	0.1	3.6	1	0.1	3	89
58	036-04-0049	LA4	7.15	5928	48	4.8	0.10	0.1	0.1	3.6	1	4.8	9	76
58	051-03-0027	LA17	12.91	3360	62	1.6	0.15	0.8	0.1	3.6	7	0.1	3	82
61	863-02-0022	LA421	6.92	614	53	1.6	0.15	0.1	0.1	3.8	1	1.5	9	83
61	804-28-0008	LA1015	0.66	1178	55	3.2	9.00	0.1	3.6	0.1	1	1.5	9	73
61	804-29-0009	LA1015	0.76	972	55	1.6	15.00	0.8	3.6	0.1	1	1.5	12	66
61	804-38-0006	LA1016	3.85	1777	.	.	.	.	.	.	.	.	.	.
61	804-20-0003	LA999	1.29	418	55	12.0	9.00	0.8	3.6	3.6	3	1.5	15	52
62	859-09-0017	LA430	8.83	1242	42	3.2	0.15	0.1	0.1	10.0	1	6.0	9	70
62	278-05-0005	LA1061	4.56	827	42	1.6	1.20	0.8	3.6	6.4	3	4.8	9	72
62	260-09-0005	LA441	3.80	1028	59	20.0	0.15	0.1	0.1	6.4	3	4.8	12	55
62	260-06-0009	LA43	3.69	3154	59	1.6	0.15	0.1	0.1	4.8	3	4.8	9	76

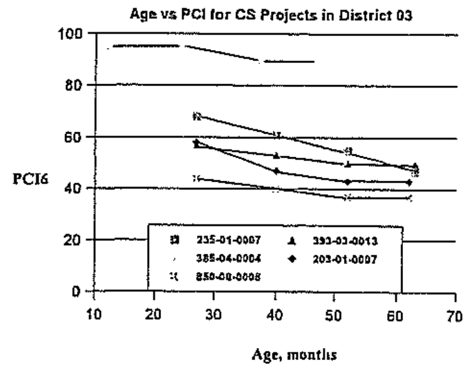


Figure 7.1a: Age vs PCI for chip seal projects in District 03

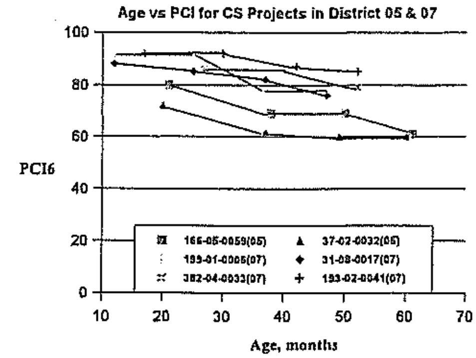


Figure 7.1c: Age vs PCI for chip seal projects in District 05 & 07

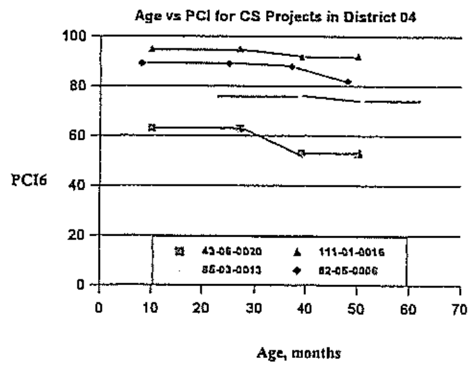


Figure 7.1b: Age vs PCI for chip seal projects in District 04

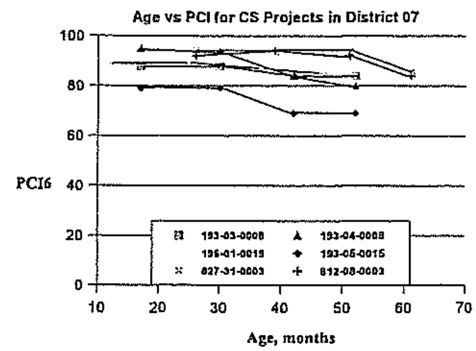


Figure 7.1d: Age vs PCI for chip seal projects in District 07

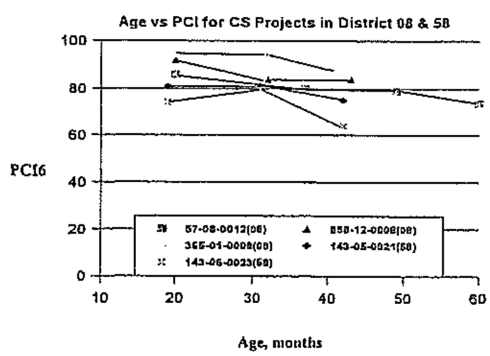


Figure 7.1e: Age vs PCI for chip seal projects in District 08 & 58

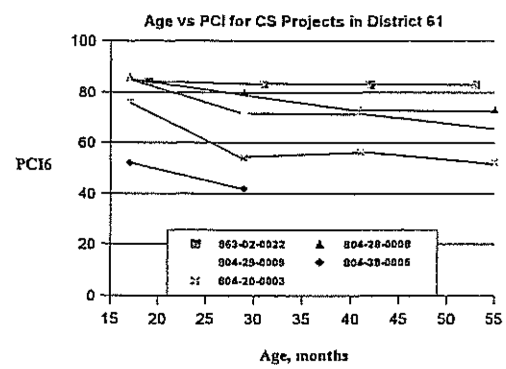


Figure 7.1g: Age vs PCI for chip seal projects in District 61

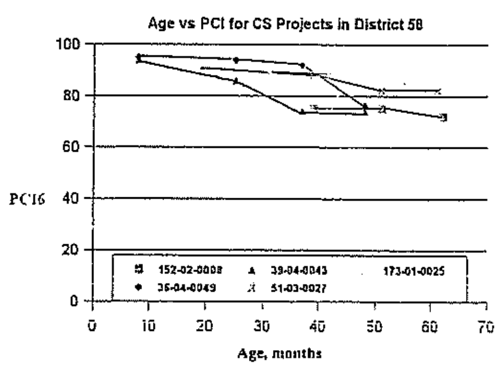


 Figure 7.1f: Age vs PCI for chip seal projects in District 58

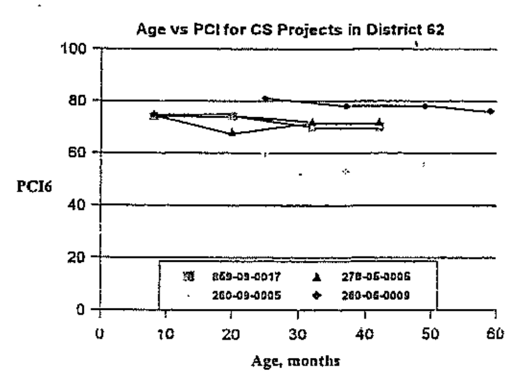


Figure7.1h: Age vs PCI for chip seal projects in District 62

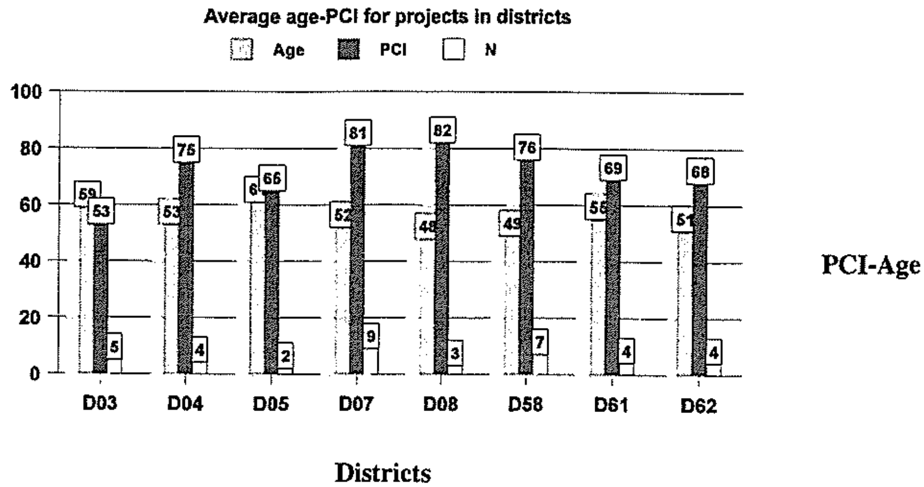
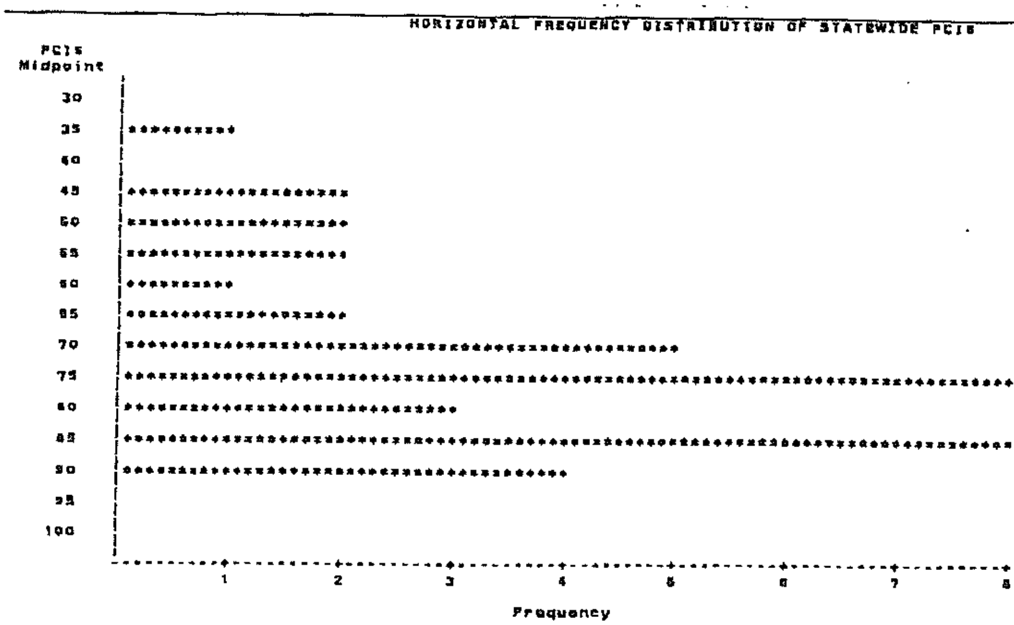


Figure 7.2: Time (age) -Performance (PCI) relationship of projects in districts



PCIS Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
30	0	0	0.00	0.00
35	1	1	2.63	2.63
40	0	1	0.00	2.63
45	2	3	5.26	7.89
50	2	5	5.26	13.16
55	2	7	5.26	18.42
60	1	8	2.63	21.05
65	2	10	5.26	26.32
70	5	15	13.16	39.47
75	8	23	21.05	60.53
80	3	26	7.89	68.42
85	8	34	21.05	89.47
90	4	38	10.53	100.00
95	0	38	0.00	100.00
100	0	38	0.00	100.00

Figure 7.3: Frequency distribution of PCI

Effect of Pretreatment Pavement Condition on Performance

One of the objectives of the SHRP SPS-3 and SPS-4 experiments (2) was to determine the optimum timing for treatment application *(2,3)*. Timing in this context signifies the condition of the pavement before treatment is applied. Even without the benefit of analysis, logic would dictate that treatment applied over completely deteriorated pavements would not last as long as that applied to fair or good pavements. A recent study on SPS-3 sections in the southern region indicated that the application of chip seal to poor condition pavement increases the risk of failure by two to four times *(4)*.

To evaluate this effect of timing, preconstruction condition data was extracted from DOTD's PMS (ARAN) file. Tables 7.3 and 7.4 list this data on selected distress. In the table, the negative values under the variable AGE1 represent the time prior to treatment application. Note that the time between this survey data and treatment application varies from just two months to as much as two years. The two-year period is a long enough time to alter the condition just before the application. Likewise, no documentation was available relative to any routine maintenance that may have been applied to the project during this period. This was a major shortcoming. However, for this analysis, it is assumed that the condition did not change much just prior to treatment application.

Table 7.3: ARAN random cracking and roughness data on chip seal projects

DIST	PROJ_NO	RTE	LENG	ADT	AGE1	IRI1	RCRACKL1	RCRACKM1	RCRACKH1	AGE2	IRI2	RCRACKL2	RCRACKM2	RCRACKH2	AGE8	PCI8
3	235-01-0007	LA328	4.20	3272	-3	188	38	114	2	31	157	450	337	248	83	47
3	393-03-0013	LA343	5.23	2254	-3	129	278	404	5	31	114	88	13	1	83	50
3	385-04-0004	LA32	2.70	528	-18	257	577	3	70	18	221	48	11	0	87	50
3	203-01-0007	LA23	4.14	2886	-3	175	38	261	0	31	172	834	204	0	82	43
3	850-08-0008	LA382	2.84	1714	-2	185	121	0	100	32	185	1171	405	0	82	37
4	043-05-0020	LA9	7.45	2578	-17	141	334	318	0	7	158	108	92	0	50	83
4	111-01-0016	LA531	7.82	318	-17	83	82	814	0	7	88	14	3	0	80	82
4	065-03-0013	LA160	6.28	319	-5	170	0	2245	0	15	173	24	0	0	82	74
4	082-05-0008	LA157	7.33	887	-20	117	483	457	0	5	128	82	20.	0	48	83
5	188-05-0005	LA132	4.99	1066	-5	173	0	0	1843	19	176	123	86	0	81	89
5	037-02-0032	LA2	9.00	3837	-8	181	160	887	4	18	135	101	181	18	80	80
7	169-01-0008	LA102	7.43	489	-16	104	5	1174	0	16	103	567	105	0	47	78
7	031-08-0017	LA27	11.72	2950	-19	114	0	2177	0	18	114	218	18	1	47	78
7	382-04-0033	LA384	5.88	1211	-3	145	820	4	0	31	108	50	0	0	.	.
7	193-02-0041	LA27	5.45	3328	-13	108	8	8	0	21	116	7	0	0	52	85
7	193-03-0008	LA27	2.13	2988	-13	93	316	1470	0	21	112	41	8	0	52	84
7	193-04-0008	LA27	8.24	1245	-13	106	0	2338	0	21	100	188	32	14	52	84
7	198-01-0019	LA14	7.27	3249	-18	110	18	200	0	18	105	138	81	0	47	85
7	193-05-0015	LA14	4.97	3520	-13	89	12	123	0	21	83	185	34	0	52	88
7	827-31-0003	LA3058	1.88	519	-4	173	0	2146	89	30	159	7	11	15	81	88
7	812-08-0003	LA3059	2.33	519	-11	203	0	1580	0	23	257	.	.	.	81	86
8	057-08-0012	US167	3.57	590	-11	111	41	327	0	27	114	897	45	0	80	74
8	858-12-0001	LA489	2.80	248	-28	187	0	72	1429	-1	170	0	317	1040	43	84
8	385-01-0008	LA472	8.77	199	-28	148	538	528	298	-1	154	88	844	3	41	88
58	143-05-0021	LA124	5.48	628	-24	.	.	.	.	.	.	.	.	.	42	78
58	143-08-0023	LA124	8.38	783	-24	115	38	404	0	1	124	73	34	0	42	86
58	152-02-0008	LA8	2.29	1257	-4	148	0	1388	328	30	188	8	484	14	82	73
58	039-04-0043	LA8	3.83	2898	.	.	.	.	.	.	.	.	.	.	48	74
58	173-01-0025	LA4	4.85	803	-27	144	1008	1384	0	0	178	31	4	1	42	85
58	038-04-0045	LA4	7.15	5828	-24	120	2128	242	0	19	144	1	0	0	48	78
58	051-03-0027	LA17	12.31	3380	-8	105	848	478	8	30	111	77	57	0	82	82
61	883-02-0022	LA421	8.92	814	-19	.	.	.	.	24	.	.	.	.	53	83
61	804-25-0008	LA1015	0.88	1178	-22	228	58	4	0	22	258	44	4	1	58	73
61	804-35-0009	LA1015	0.78	872	-22	317	89	64	0	22	250	138	83	1	58	58
61	804-36-0008	LA1018	3.86	1777	-22	382	2	10	0	22	228	8	8	0	.	.
61	804-30-0003	LA898	1.29	418	-12	283	58	110	0	23	248	28	0	0	55	52
62	868-08-0017	LA430	8.43	1242	-22	.	.	.	.	11	.	.	.	.	42	70
62	278-05-0005	LA1081	8.58	827	-2	.	.	.	.	32	.	.	.	.	42	72
62	280-05-0005	LA441	3.80	1028	-8	123	335	1307	78	28	172	509	38	0	59	65
62	280-08-0009	LA43	3.88	3154	-8	138	438	1003	79	25	130	87	117	31	58	78

Table 7.4: ARAN alligator cracking and rutting data on chip seal projects

DIST	PROJ_NO	RTE	LENG	ADT	AGE1	RUT1	ACRACKL1	ACRACKM1	ACRACKH1	AGE2	RUT2	ACRACKL2	ACRACKM2	ACRACKH2	AGE4	PCI8
3	233-01-0007	LA329	4.20	3272	-3	0.30	0	648	137	31	0.27	1	41	30	63	47
3	383-03-0013	LA343	6.23	2254	-3	0.29	341	770	127	31	0.32	37	18	1	63	50
3	355-04-0004	LA82	2.70	328	-18	0.27	41	183	0	18	0.33	0	2	1	47	50
3	203-01-0007	LA28	4.14	2898	-3	0.29	0	413	8	31	0.32	0	0	0	62	63
3	850-08-0008	LA352	2.84	1714	-3	0.43	0	1634	48	32	0.47	50	7	0	83	37
4	043-08-0020	LA9	7.48	2578	-17	0.20	0	188	0	7	0.20	2	0	0	50	83
4	111-01-0018	LA531	7.82	518	-17	0.20	0	18	0	7	0.20	0	0	0	50	92
4	085-03-0013	LA160	8.28	319	-6	0.18	830	8	0	18	0.24	15	31	0	62	74
4	082-05-0008	LA157	7.22	887	-20	0.25	178	9	8	5	0.28	2	0	0	44	82
5	188-05-0005	LA133	4.88	1088	-6	0.18	0	0	3	18	0.24	0	0	0	81	88
5	037-02-0032	LA2	9.00	3837	-8	0.30	133	686	123	18	0.20	0	0	0	60	80
7	195-01-0008	LA102	7.43	488	-18	0.18	83	324	0	18	0.20	0	0	0	47	78
7	031-08-0017	LA27	11.72	3580	-15	0.28	0	1419	38	19	0.31	14	0	1	47	78
7	382-04-0033	LA384	6.88	1211	-3	0.37	683	0	0	31	0.34	-0	0	0	.	.
7	193-02-0041	LA27	5.65	3328	-13	0.48	547	241	0	21	0.50	0	0	0	62	88
7	193-03-0008	LA27	2.13	2384	-13	0.58	85	528	0	21	0.80	22	0	0	52	84
7	183-04-0006	LA27	8.74	1248	-13	0.81	0	832	18	21	0.48	53	4	0	92	84
7	198-01-0019	LA18	7.27	3248	-18	0.27	39	358	2	18	0.31	79	0	0	47	85
7	193-05-0015	LA14	4.97	3620	-13	0.80	270	229	0	21	0.43	3	0	0	52	88
7	827-31-0003	LA3088	1.88	519	-4	0.20	0	202	838	30	0.29	8	0	0	81	88
7	812-08-0003	LA3088	2.33	819	-11	0.28	0	338	444	23	.	.	.	.	81	86
8	087-08-0012	US187	3.57	880	-11	0.20	0	10	0	27	0.20	1	0	0	80	74
8	858-12-0001	LA468	2.80	248	-28	0.12	0	0	0	-1	0.17	1	8	2	43	84
8	383-01-0008	LA472	3.77	189	-28	0.20	97	258	83	-1	0.15	31	60	0	41	88
58	143-05-0021	LA124	5.48	826	-24	.	.	.	.	.	.	.	.	.	42	75
58	143-08-0023	LA124	4.38	783	-24	0.30	125	84	0	1	0.28	0	0	0	42	84
58	152-02-0008	LA8	2.29	1257	-4	0.20	0	4338	0	20	0.20	2	0	0	62	72
58	035-04-0043	LA8	3.83	2199	.	.	.	.	.	.	.	.	.	.	48	74
58	173-01-0025	LA4	4.88	809	-27	0.18	0	82	1	0	0.32	0	0	0	42	88
58	038-04-0045	LA4	7.15	5828	-24	0.28	0	368	83	19	0.38	0	0	0	48	78
58	051-03-0027	LA17	12.91	3380	-4	0.25	4	2	0	20	0.30	0	0	0	83	82
61	883-02-0022	LA421	8.52	814	-19	.	.	.	.	24	.	.	.	.	83	83
61	804-28-0008	LA1015	0.88	1178	-22	0.30	103	862	0	22	0.30	83	0	0	65	73
61	804-29-0003	LA1015	0.78	972	-22	0.40	82	53	0	22	0.30	231	164	38	58	88
61	804-38-0008	LA1018	3.85	1777	-22	0.30	5	0	0	22	0.40	4	0	0	.	.
61	804-20-0003	LA889	1.28	418	-12	0.20	73	238	0	22	0.30	142	24	0	56	82
62	838-05-0017	LA430	8.83	1242	-22	.	.	.	.	11	.	.	.	.	42	70
62	278-05-0003	LA1081	4.56	827	-2	.	.	.	.	32	.	.	.	.	42	72
62	280-08-0005	LA441	3.80	1028	-8	0.18	0	0	0	29	0.21	5	0	0	88	25
62	280-08-0008	LA43	3.85	3154	-8	0.38	0	0	0	29	0.34	19	15	2	88	78

The pavements were classified as in good, fair, and poor condition according to the distress levels defined in the table 7.5 below. For random cracking (a combination of longitudinal, transverse, and block cracking) and alligator cracking, the condition categories are for moderate severity distress levels. Roughness and rutting were included because they have some effect on other attributes and to each other. However, it is recognized that chip seal does not have a direct impact on roughness and rutting.

Table 7.5: Condition Category Based on Selected Distress

Distress	Level		
	Good(1)*	Fair(2)	Poor(3)
Random Cracking	≤500 ft	501-1500 ft	>1500 ft
Alligator Cracking	≤700 sq ft	701-1500 sq ft	>1500 sq ft
Rutting	≤0.25 in	0.26-0.50 in	>0.50 in
IRI Roughness	≤100	101-175	>175

*** numeric rating of condition level**

Based on these factors and the uniform application of the condition categories across all sections, it is felt that an adequate comparison can be made of these sections. Table 7.5 lists the condition category based on the moderate severity level. Using this as a guide and the data in tables 7.3 and 7.4, the condition category for each section was assigned. These condition categories are based on the cracking distress only, and the categories for each distress are shown in Appendix A; table A2. Further, if the condition category was different for the two cracking attributes, the lower of the two was assigned (last column in the table A2).

Figure 7.4 or effect of pre condition on performance is a general plot of the cracking condition levels (1, 2, or 3 shown in Table A2) versus current PCI. Based on the distress and condition level, the effect of pretreatment pavement condition on the performance (PCI) is ill-defined. Two possible explanations can be advanced. One is that poor construction contributes to early decline in PCI even on good condition pavements, and the other is surface preparation, which, if done properly even on poor condition pavements, may retard PCI decline. However, no documentation exists to relate to either explanation.

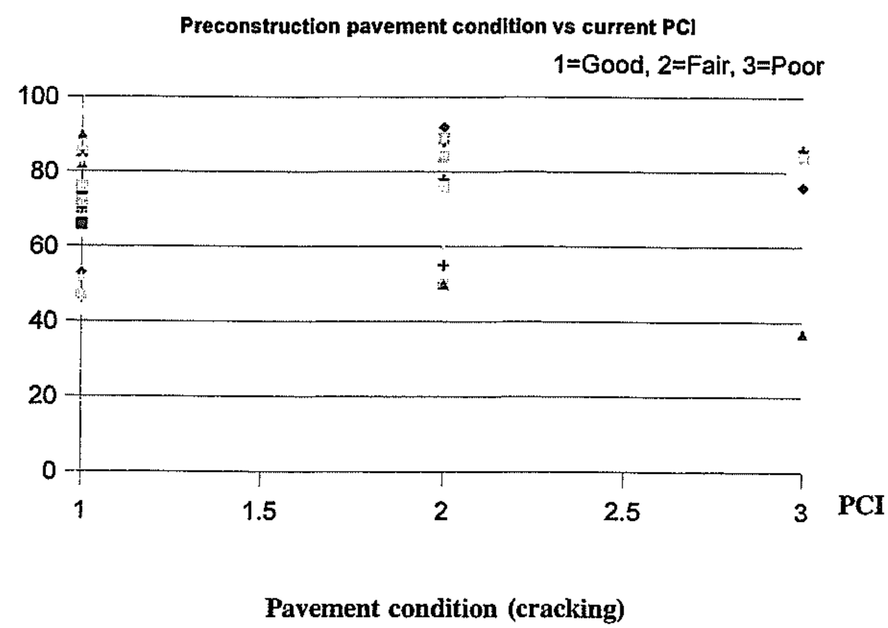
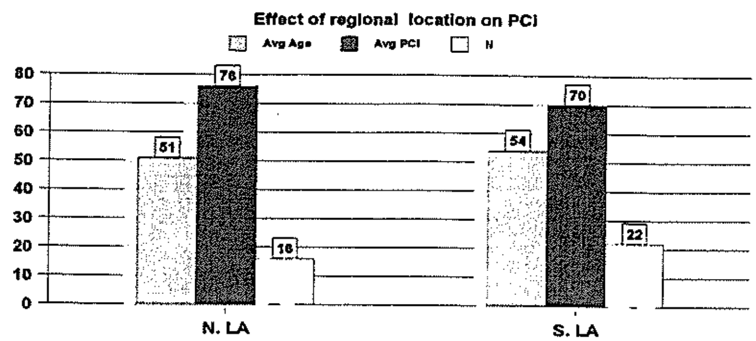


Figure 7.4: Effect of pretreatment pavement condition on performance

Effect of Traffic on Performance

Most of the chip seals are applied on low volume roads (< 1000ADT), although a number of sections carry between 2000 and 3000 ADT (Average Daily Traffic). The T-Test, testing whether the two means are different, showed the effect of the two levels of traffic on PCI to be statistically significant at the 0.01 level. This is shown in Figure 7.5.

PCI-Age



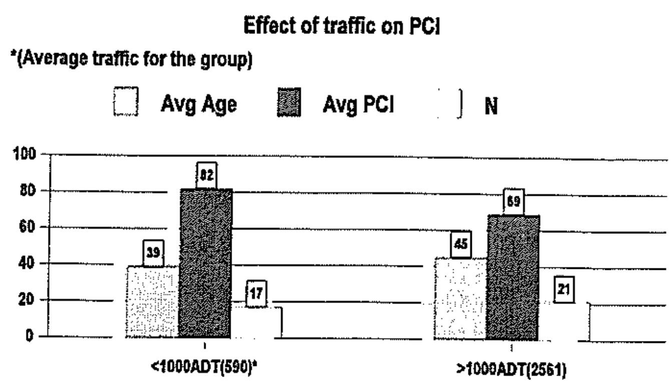
Traffic level

Figure 7.5: Effect of traffic levels on performance

Effect of Region

Location in this context refers to the northern and southern regions of Louisiana where the environment conditions are different. Figure 7.6 is a bar chart of PCI for the two regions. The T-Test did not show the difference in the PCI between the two regions at the 0.05 level to be statistically significant.

PCI-Age



Region

Figure 7.6: Regional effect on performance

Effect of Thickness

Using the ARAN-measured GPR (Ground Penetrating Radar) thickness, the effect of thin (<6") and thick (>6") pavement section on PCI is shown in figure 7.7. The difference in PCI was found to be statistically insignificant by the T-Test at the 0.05 level. This may indicate that preventive maintenance may be more effective than a two-lift (3.5 in) overlay.

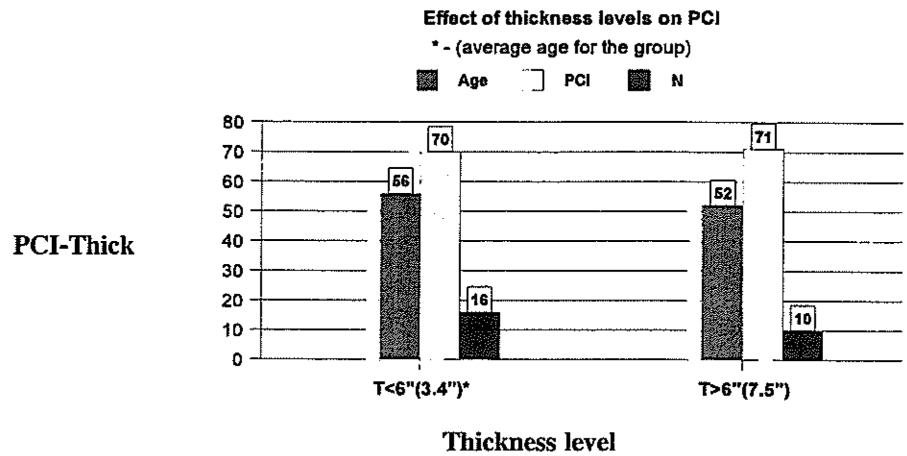


Figure 7.7: Effect of thickness levels on performance

Safety Evaluation

With the exception of some sections in District 03, the friction numbers (FN) on most of the sections are in the 30 to 60 range. Table 7.6 shows data on FN for smooth and ribbed tires for all sections. Unfortunately, no comparative data on FN before the application of treatment was available to determine the change or improvement in FN after treatment. The FN for smooth and ribbed tires are shown in figures 7.8a through 7.8d.

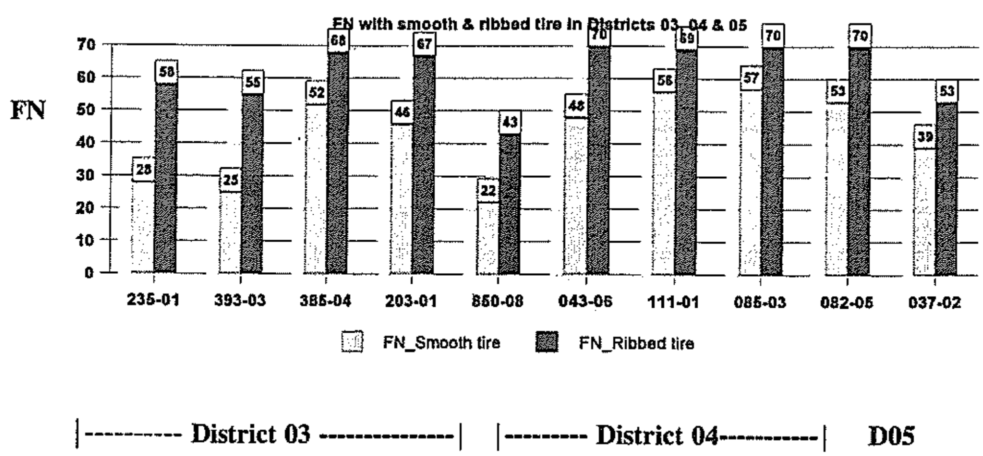
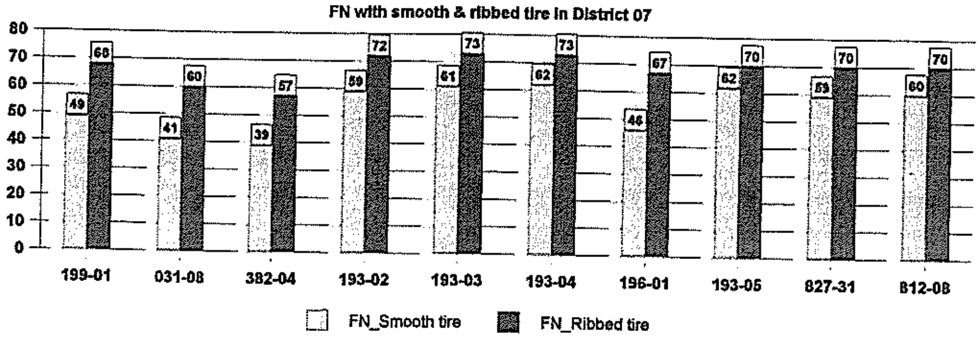


Figure 7.8a: Friction Numbers on projects in Districts 03, 04 and 05

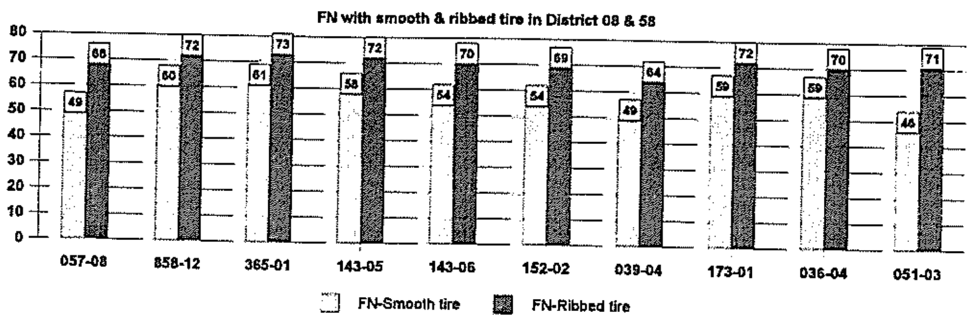
FN



District 07

Figure 7.8b: Friction Numbers on projects in District 07

FN

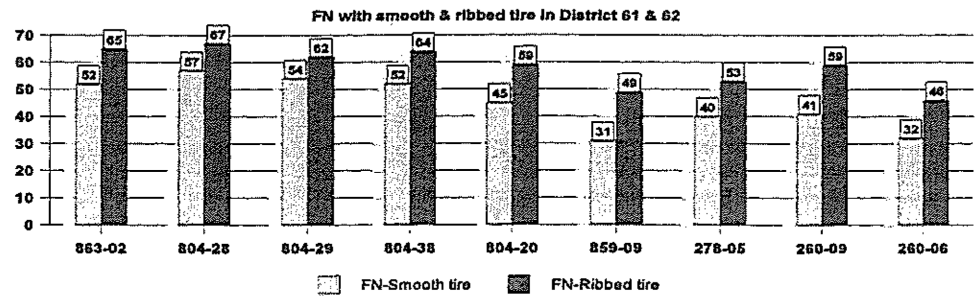


|---------D08 ---------| |---------------------------District 58 ---------------------|

Figure 7.8c: Friction Numbers on projects in District 08 & 58

The numbers for the smooth tire indicate the hydroplaning potential while the ribbed tire numbers indicate the frictional resistance generally associated with aggregate characteristics. With the exception of some sections in District 03 and 62, none of the sections show any safety concerns due to either hydroplaning or polished aggregate.

FN



|------------------ **District 61** ----------------| |---------------**District 62** ---------|

Figure 7.8d: Friction Numbers on projects in District 61 & 62

Table 7.6: DOTD Friction Numbers (FN) and rutting data on chip seal projects

DIST	PROJ_NO	RTE	LENG	ADT	THICK	COST	AVG_RUT	AVG_IRI	FN_S	FN_R	AGES	PCIA
3	235-01-0007	LA329	8.20	3272	3.7	1.21	0.47	178	37.7	58.1	83	47
3	353-03-0013	LA343	6.23	2254	8.1	1.33	0.52	124	25.1	55.4	83	50
3	385-04-0004	LA82	2.70	626	2.9	2.33	0.31	288	33.3	57.8	47	50
3	203-01-0007	LA25	4.14	2985	4.7	1.30	0.27	172	48.2	68.8	82	43
3	460-06-0008	LA352	2.84	1714	8.3	1.31	0.57	188	21.5	43.2	82	37
4	043-08-0020	LA8	7.49	2578	5.8	1.32	.	.	46.2	65.6	50	63
4	111-01-0016	LA531	7.82	518	3.9	1.30	.	.	68.3	68.7	50	82
4	085-03-0013	LA180	8.28	319	2.8	1.28	.	.	57.3	68.6	82	74
4	082-05-0008	LA157	7.22	487	3.5	1.19	.	.	52.8	70.3	48	82
5	188-05-0005	LA332	4.85	1065	3.9	1.09	.	.	.	.	81	88
5	037-02-0032	LA2	5.00	3637	7.5	1.41	.	.	38.5	52.8	80	80
7	189-01-0008	LA102	7.43	488	.	1.08	.	.	42.1	68.0	47	78
7	031-08-0017	LA27	11.72	3850	7.4	1.28	0.42	121	40.3	60.1	47	78
7	382-04-0033	LA384	5.88	1211	8.0	1.38	.	.	38.1	57.1	.	.
7	153-02-0041	LA27	5.45	3328	.	1.26	0.29	122	36.8	71.9	52	86
7	153-03-0008	LA27	2.13	2588	11.1	1.31	0.32	114	60.7	72.9	52	84
7	153-04-0005	LA27	8.24	1248	.	1.16	0.31	103	51.8	72.7	52	84
7	188-01-0019	LA14	7.27	3249	.	1.10	.	.	48.5	67.1	47	88
7	163-06-0015	LA14	4.97	3820	.	1.13	0.30	87	61.8	70.4	52	89
7	827-31-0003	LA3068	1.88	319	2.1	1.44	.	.	58.5	70.4	81	88
7	812-08-0003	LA3058	2.33	519	1.9	1.57	.	.	59.5	70.2	61	64
8	057-08-0012	US167	3.57	590	.	1.53	0.32	112	49.2	68.2	80	74
8	858-12-0001	LA489	2.80	248	2.2	.	.	.	60.2	73.3	43	84
8	365-01-0008	LA472	8.77	199	8.4	.	.	.	61.4	73.3	41	88
58	143-05-0021	LA124	5.48	828	.	0.38	.	.	57.7	71.8	42	76
58	143-06-0023	LA124	4.38	783	7.0	1.04	.	.	53.6	70.3	42	84
58	162-02-0008	LA8	2.29	1257	5.0	1.39	.	.	53.7	64.9	82	72
58	035-04-0043	LA8	3.43	2999	.	1.10	.	.	68.8	66.4	48	74
58	173-01-0025	LA4	4.88	808	8.3	1.06	.	.	68.6	71.7	42	89
58	039-04-0048	LA4	7.15	5828	7.9	1.41	.	.	58.5	70.4	48	76
58	051-03-0027	LA17	12.91	3380	6.9	1.28	.	.	43.5	71.0	82	82
61	863-02-0022	LA421	8.92	814	.	1.09	0.33	271	52.1	64.8	53	83
61	804-28-0008	LA1019	0.88	1178	.	1.58	.	.	57.2	67.1	68	73
61	804-29-0005	LA1015	0.78	572	2.7	1.37	.	.	53.9	62.3	65	88
61	804-38-0008	LA1018	3.65	1777	2.8	1.40	0.43	227	52.0	64.0	.	.
61	804-20-0003	LA989	1.25	418	3.5	1.88	0.30	253	44.7	58.3	55	62
62	859-09-0017	LA430	6.03	1242	.	1.13	.	.	30.8	48.8	42	70
62	278-05-0005	LA1061	4.80	827	.	1.04	.	.	39.6	53.2	42	72
62	260-09-0006	LA441	3.60	1028	3.8	1.38	0.14	121	41.3	58.9	58	88
62	260-06-0005	LA43	3.85	3154	2.8	1.85	0.17	117	32.1	45.7	58	78

Miscellaneous Analysis

ARAN Before and After Survey Data Evaluation

As was noted earlier, DOTD collects data on the condition of the state network every two years through a contract with ARAN. The type of data collected is shown in table 4.2. For the present study, two sets of data were available for evaluation. The first one was collected in 1995 and formed the basis for the preconstruction information on study sections. The second ARAN survey took place from 1997 through 1998 which was used to evaluate the effects of preventive maintenance.

These two sets of ARAN data appear in tables 7.3 and 7.4. The data are average values based on one tenth of a mile segments. Notice that in some cases, the period between the two evaluations is as much as three years. Further, the pretreatment data (1995-96) for some sections were collected two years before the construction of chip seals. Taking these factors into account, the evaluation is shown in figures 7.9 through 7.11. The charts are for random and alligator cracking distress and roughness. In the figures, the before-treatment data represent only that data collected within six months of construction. The after-treatment data varies from 18 months to 32 months after treatment application. In these figures, the before and after data are presented side-by-side for each of the severity cracking levels (low, medium and high). The numbers in parenthesis after the control number represent pretreatment and post treatment age in months.

The bar charts in the figures show that, in general, there is an improvement after treatment application, although in a number of cases there has been an increase in the low severity random cracking distress. Three projects in District 03 exhibited on almost ten-fold increase in the low severity random cracking 31 months after the treatment. Distress at this level usually appears during the first few months after application, and, if not tended to in a timely manner, it will progress towards the next level soon thereafter. This is evident on sections 235-01 and 850-08. The deterioration of the pavement may also suggest that these projects may not have been the right candidates for chip seal application.

The magnitude of alligator cracking shows considerable reduction in some cases after the treatment. Likewise, there is an overall improvement in the roughness after the treatment although chip seal is not considered an alternative for improving roughness.

Cracking Distress - ARAN and Subjective Rating

Since the second survey by ARAN occured within six months of the first survey and used the subjective rating scheme of figure 5.1, it was decided to analyze the two sets of data to determine the closeness of the two evaluations, subjective and measured . The ARAN data on random and alligator cracking at the three severity levels (tables 7.3 and 7.4) were plotted against longitudinal and transverse cracking from the subjective rating evaluation (table 7.2). The relationship between the two surveys is shown in figure 7.12.

A regression analysis of ARAN measurements and a subjective (visual) measurement for random cracking has a correlation of 0.27 ($F=10.47$), which is significant at the 0.01 level. The plot for alligator cracking was too scattered to show any logical relationship. Because the ARAN data is interpreted from tapes the likelihood of errors in the interpretation of cracks (extent and severity) can be as great as the likelihood of errors in the subjective analysis.

The following sections discuss miscellaneous relational analyses of some of the subjective data to the measured data. A limitation of such analyses is the time difference between the two sets (subjective and measured), which, in some cases, was more than a year apart.

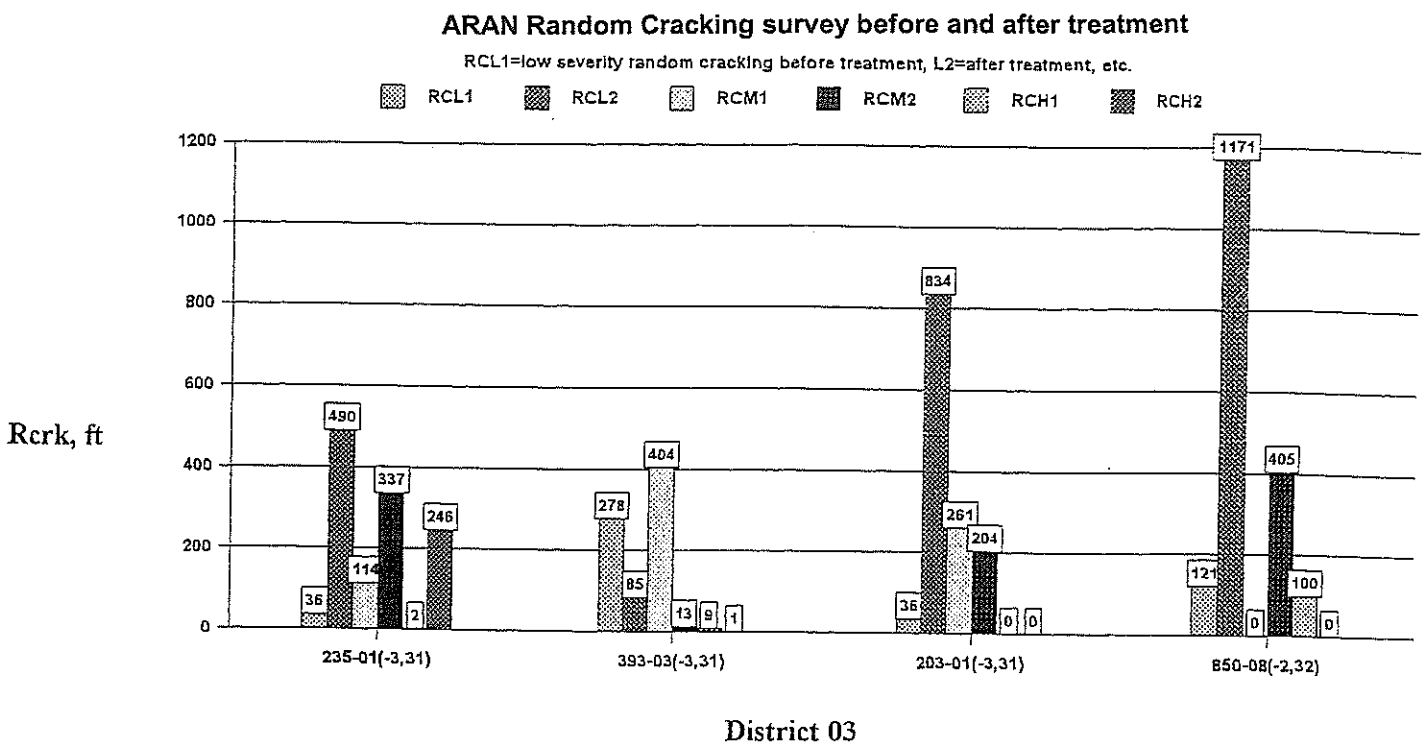


Figure 7.9a: Random cracking condition before and after chip seal treatment

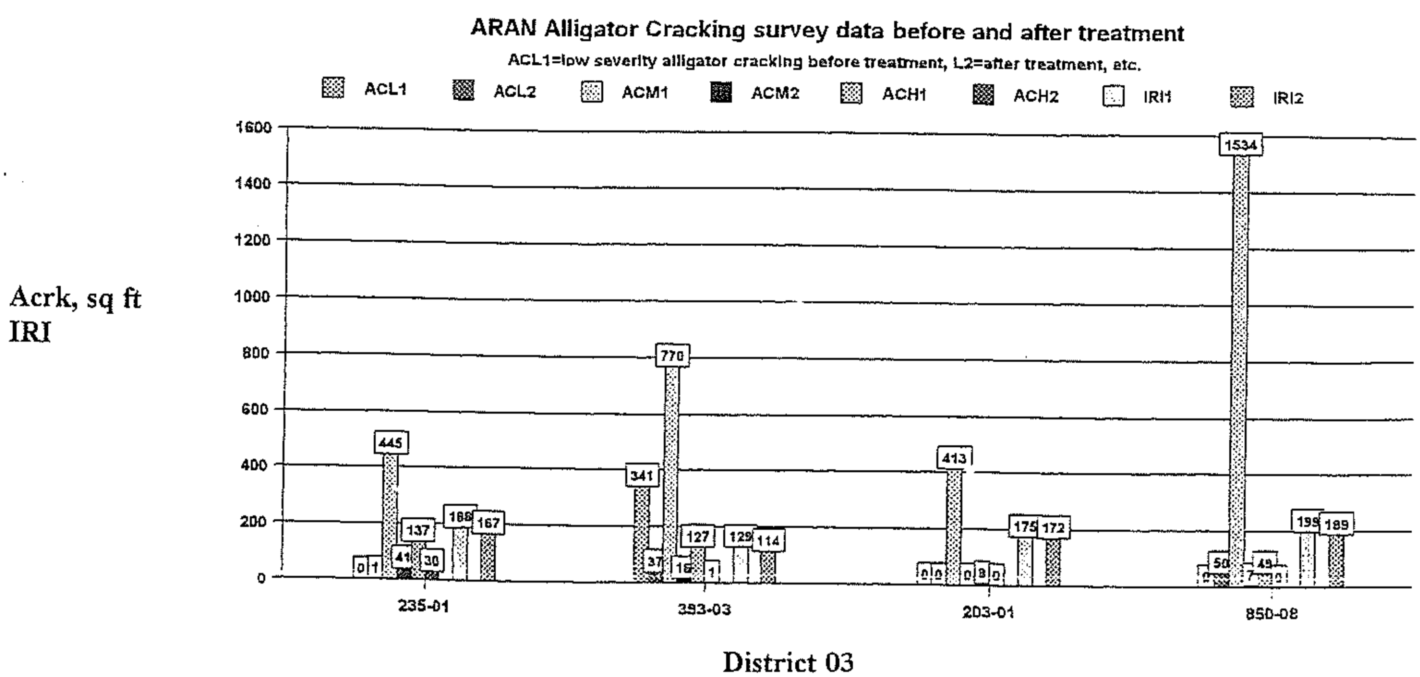


Figure 7.9b: Alligator cracking condition and IRI before and after chip seal treatment

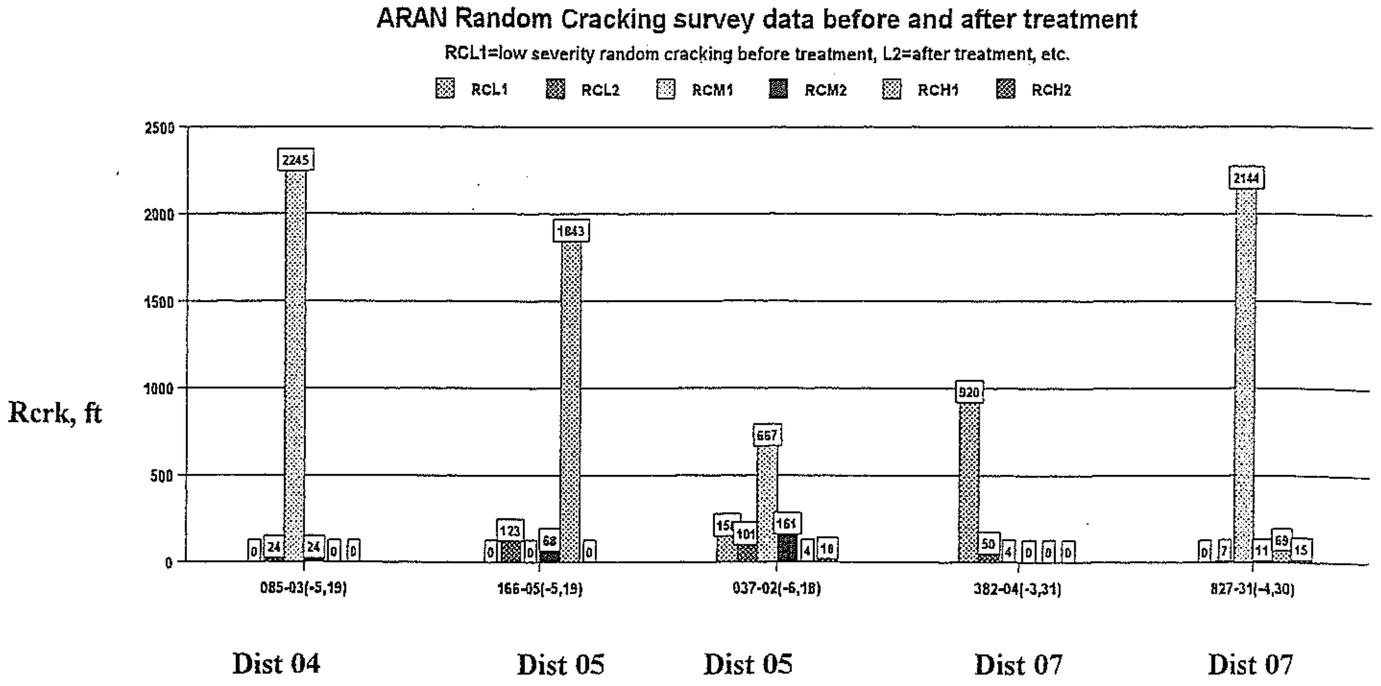


Figure 7.10a: Random cracking condition before and after chip seal treatment

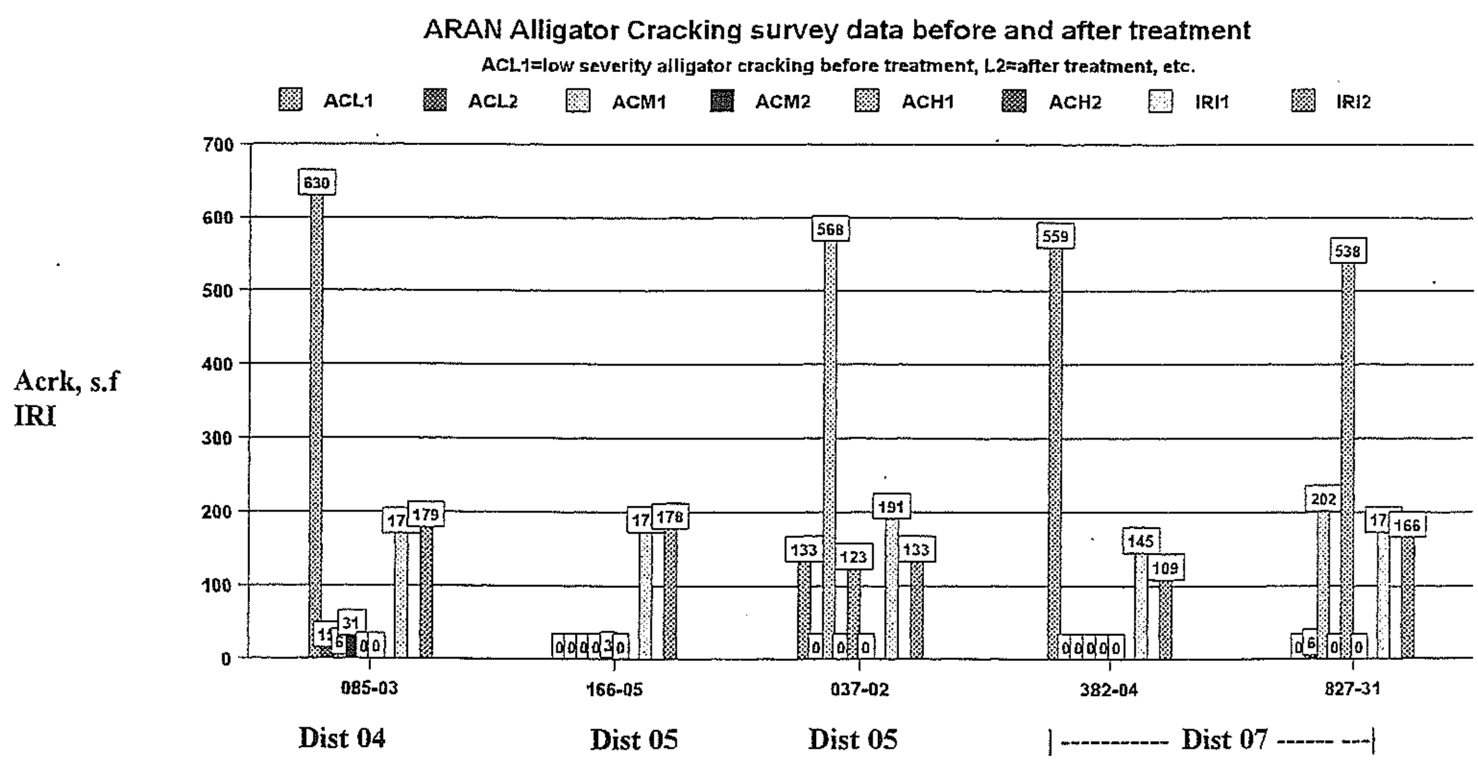


Figure 7.10b: Alligator cracking condition and IRI before and after chip seal treatment

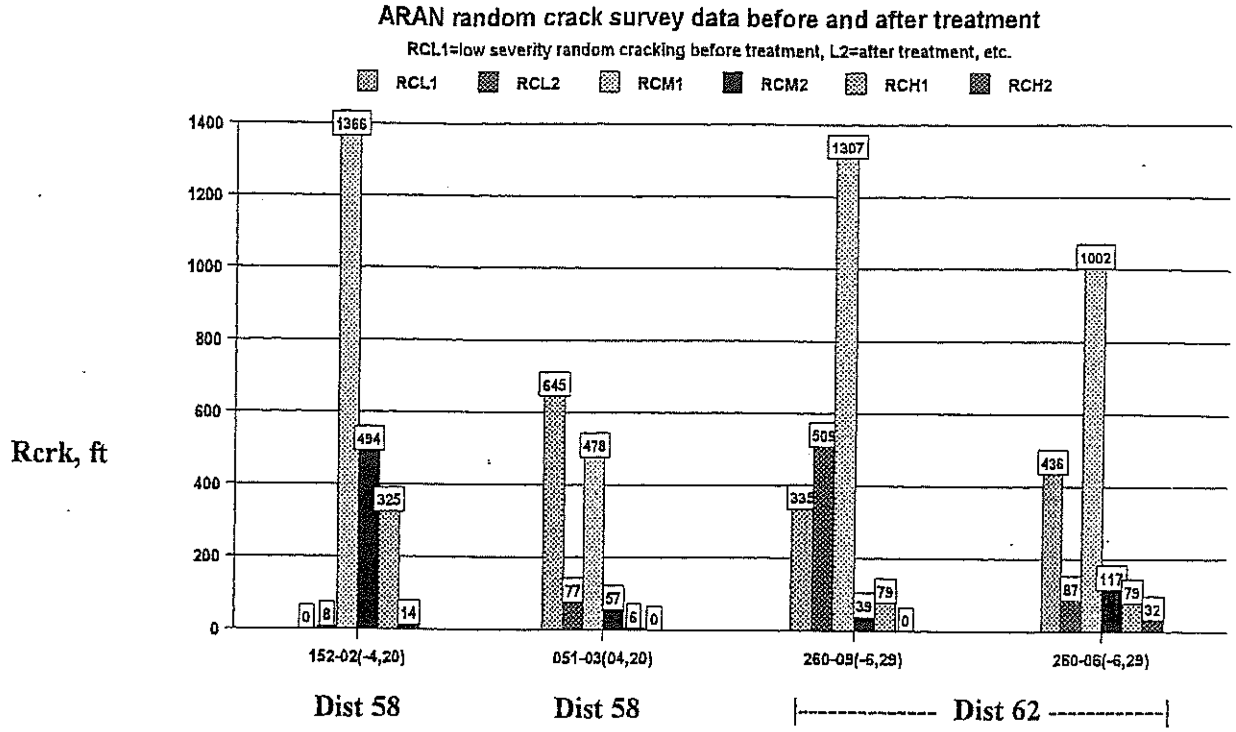


Figure 7.11a: Random cracking condition before anf after treatment

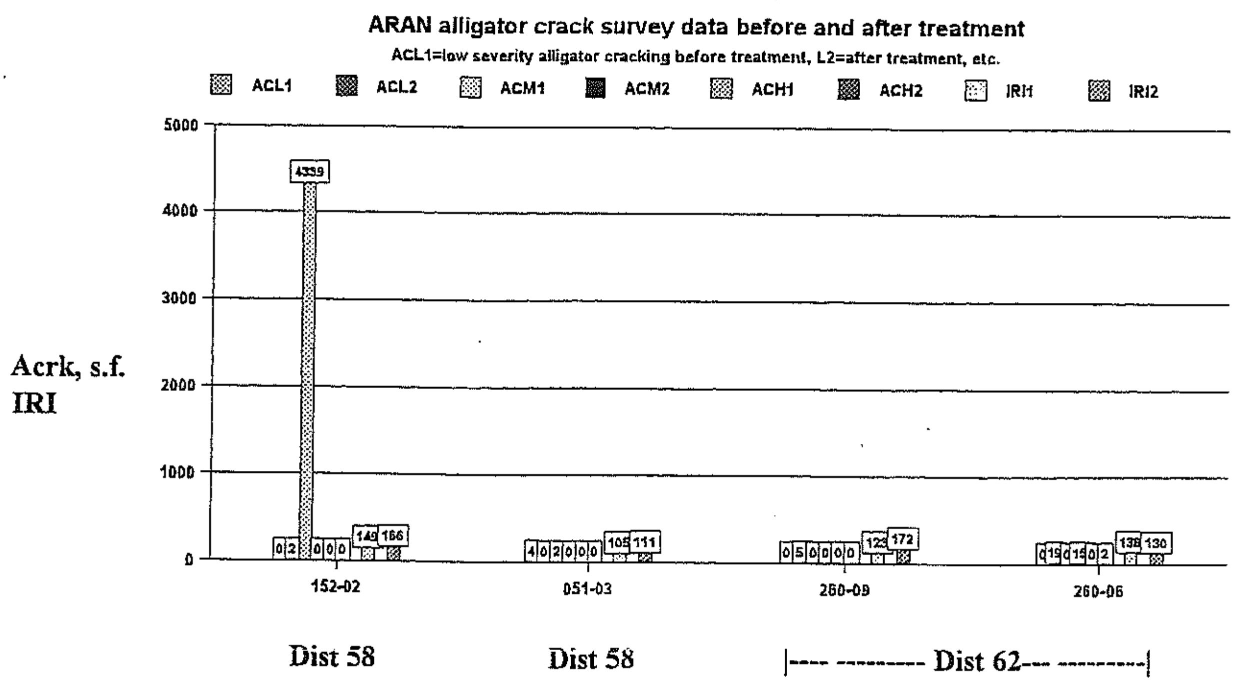


Figure 7.11b: Alligator cracking condition and IRI before and after treatment

Bleeding versus Friction Number(FN)

Figure 7.13 exhibits the relationship of bleeding and friction number to ribbed tire. The relationship is significant at the 0.001 level for an R^2 of 0.33. This means that, in the absence of measured data on FN, subjective rating can be used to take corrective action. The plot demonstrates that 27 or about 70 percent of the sections showed bleeding in general (3.6 or more in the figure) and 33 percent of that number showed medium to high severity bleeding. It should be noted (from tables in Appendix A) that these sections had exhibited this distress during the first evaluation, which was within a few months after construction. This may be indicative of construction and/or material related problems.

Aggregate Loss versus Friction Number(FN)

Loss of aggregate also increases the potential for bleeding, which can also result in loss of friction. This relationship is shown in figure 7.14. The fit is significant at the 0.001 level (R^2 =0.32, F=17.8) and follows the same trend (negative slope) as the bleeding above, which is a low friction number with increased aggregate loss.

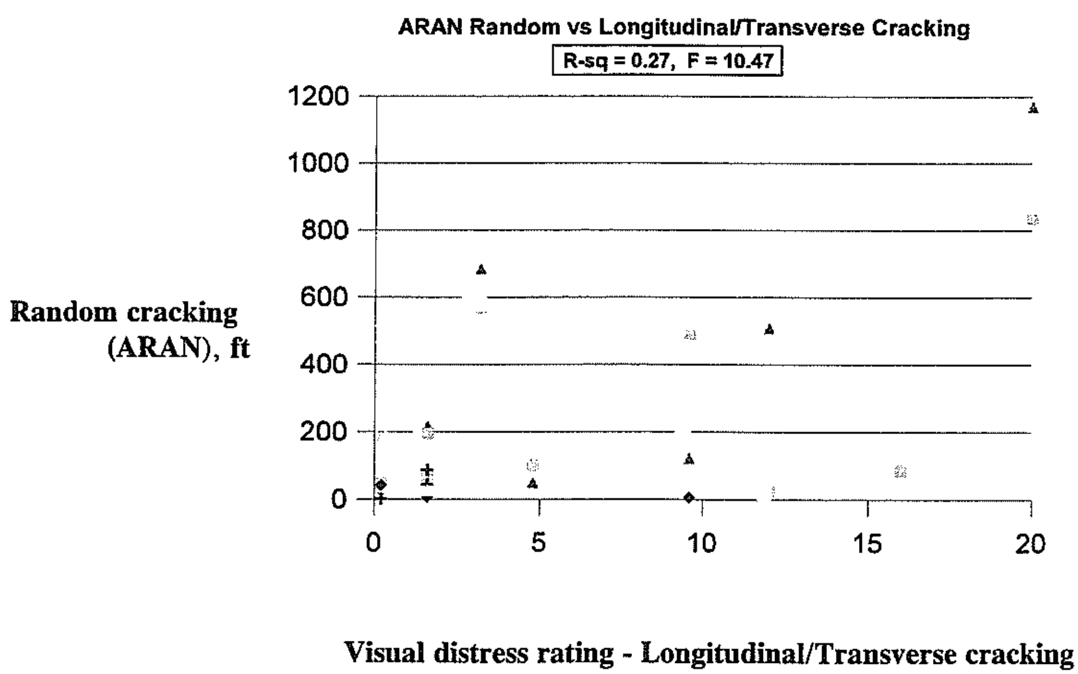


Figure 7.12: Relationship between visual distress and measured distress (ARAN) on cracking

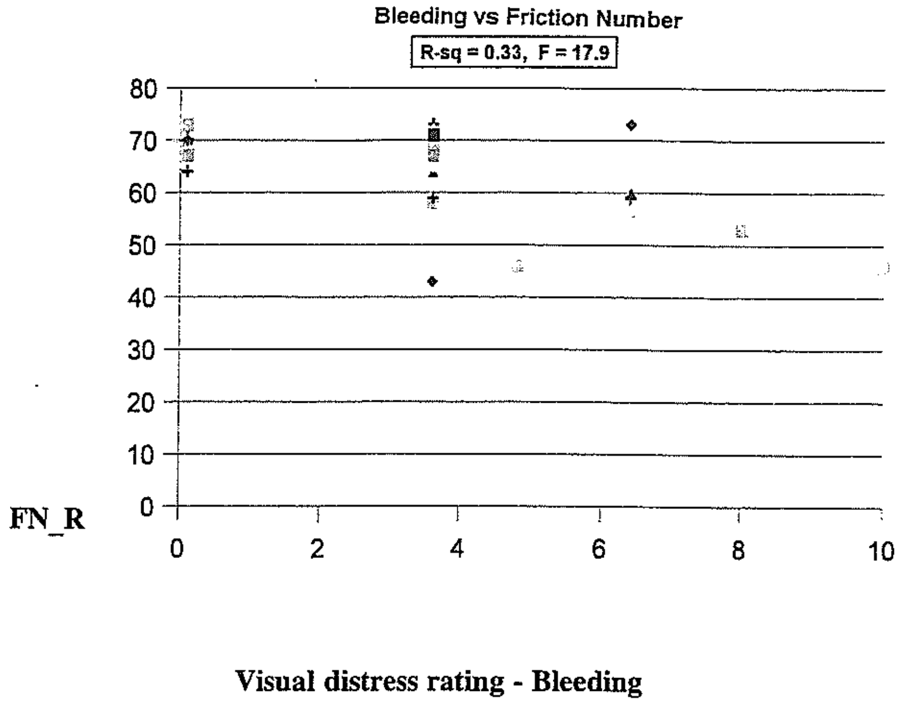


Figure 7.13: Relationship between bleeding and Friction Numbers (FN)

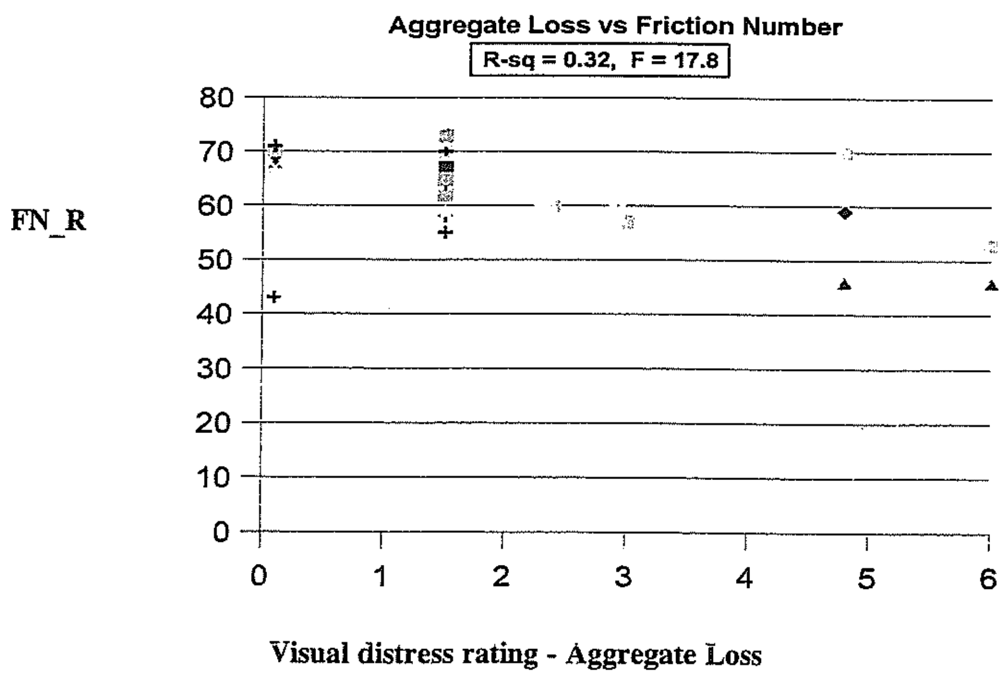
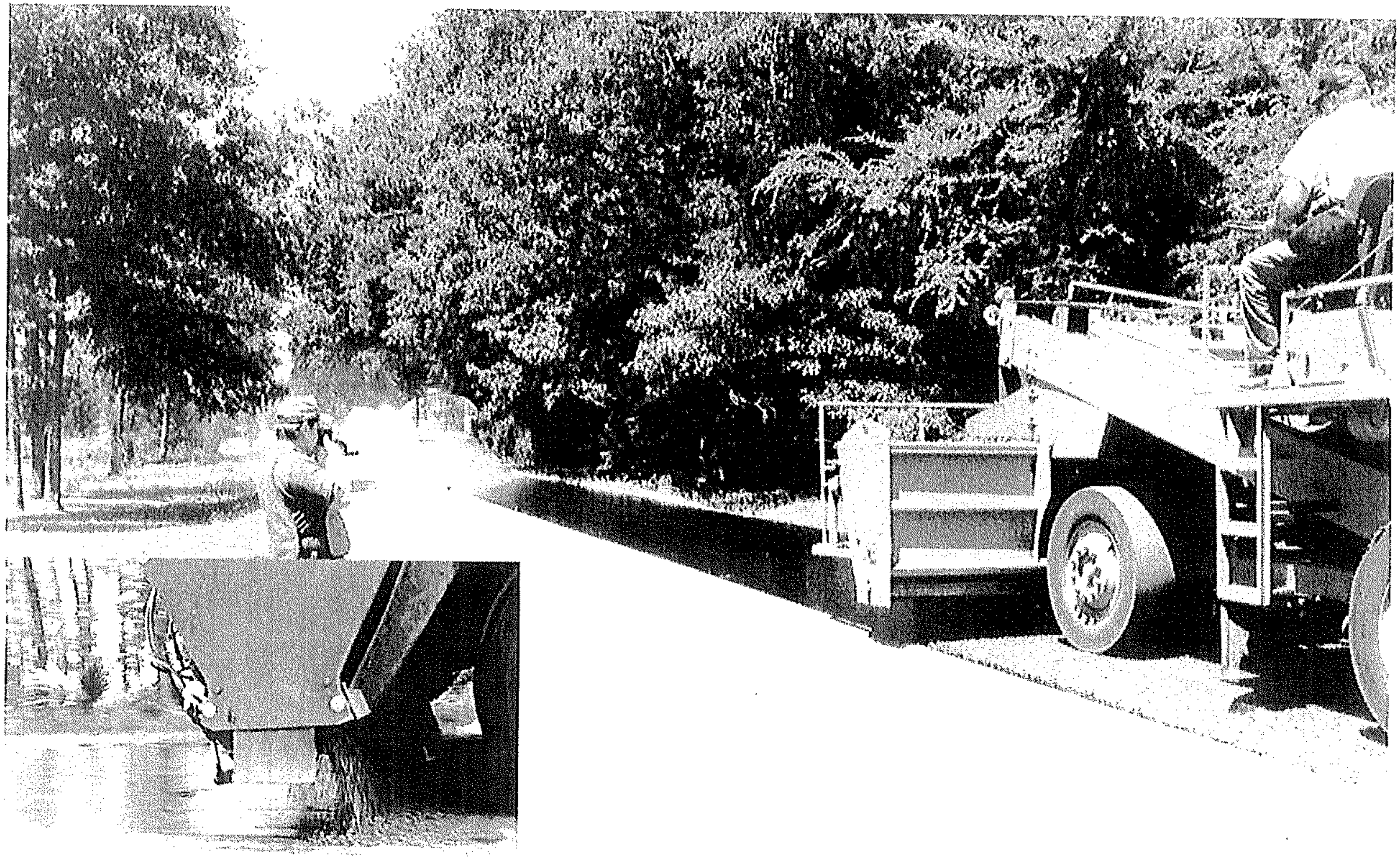


Figure 7.14: Relationship between aggregate loss and Friction Number (FN)



Chip Seal Construction

Summary

Based on four condition surveys of 40 chip seal sections, the analysis and evaluation discussed in this chapter can be summarized as follows:

- The median PCI of chip seal sections is about 75 after 52 months of service.

- Based on individual distress deduct values, a number of projects show high severity cracking (table 7.2) within two years after construction, indicating either lack of adequate preparation prior to the application of chip seal or that these pavements were not prime candidates for this type of preventive maintenance.

- In selecting the most appropriate treatment, the level and cause of distress must be considered.

- Of the 40 sections, about 70 percent have a PCI greater than 70. Three sections had a PCI of less than 50. About 10 percent were in the 50 to 60 and 60 to 70 PCI range. Two sections, one with a PCI of 42 after 41 months and the other with a PCI of 79 after 52 months, have received some form of rehabilitation.

- The effect of pretreatment pavement condition on performance was not evident from the ARAN cracking data. However, the before and after ARAN data indicate overall improvement in cracking distress due to chip seal application.

- Almost 70 percent of the sections had some bleeding with about 20 percent showing moderate to high severity bleeding. In these sections, bleeding was evident during the first evaluation, indicating a construction and/or material problem.

- Rutting was minimal with only one section exceeding 0.5 inches of ruts.

- The subjective survey of various distresses provides information that relates to measured distress and can be used for routine rating of pavements.

- The friction numbers on most of the sections are in the 30 to 60 range.

8. PERFORMANCE OF MICRO-SURFACE

Effect of Treatment Age on Performance

The four surveys for the study sections appear in table 8.1 (AGE3 to AGE6 and PCI 3 to PCI6). Table 8.2 shows the individual distress deduct values (for the last survey) contributing to the final PCI. The data in table 8.1 for the individual study sections is presented in graphic form in figures 8.1a through 8.1g. Figure 8.2 is a bar chart of the average age at last evaluation and corresponding PCI for the projects in each district. Figure 8.3 shows the frequency distribution of all PCI's regardless of age.

The flat trend of the curves in figures 8.1a through 8.1g indicates that most of the sections are still in a steady state of performance. The median statewide PCI is about 85 after almost 60 months of service. From figure 8.3, it is seen that one fourth of the projects are still in the 90s and more than half in the 80s. Two sections are in the 70s with the lowest PCI of 75 on a section in District 03 after 53 months of service.

The curves of figure 8.1 can be defined by the same equation as the chip seal performance curve of figure 7.1, which is $\mathbf{PCI = 100 - bx^m}$. The average life of micro-surface seals has been defined as 4 to 7 years but, in some instances, the seals have been designed to last for 10 years (*10*). Based on the current condition after almost five years, the sections may provide the expected service life assuming safety does not take precedence over other distress.

In considering the scale in figure 5.2, almost all can be categorized in good to excellent condition. Two projects were taken out-of-service with an overlay. One of these projects was in District 58 (Project 22-06-0042) during the period between the second and third evaluations, while the other was in District 02 (Project 148-01-0023) between the third and fourth evaluations. This project is in an urban area with several intersections and high volume of traffic. Bleeding, although not severe, was noticeable at intersections and may have prompted corrective action to enhance safety.

LA 397 --'96 Microsurfacing

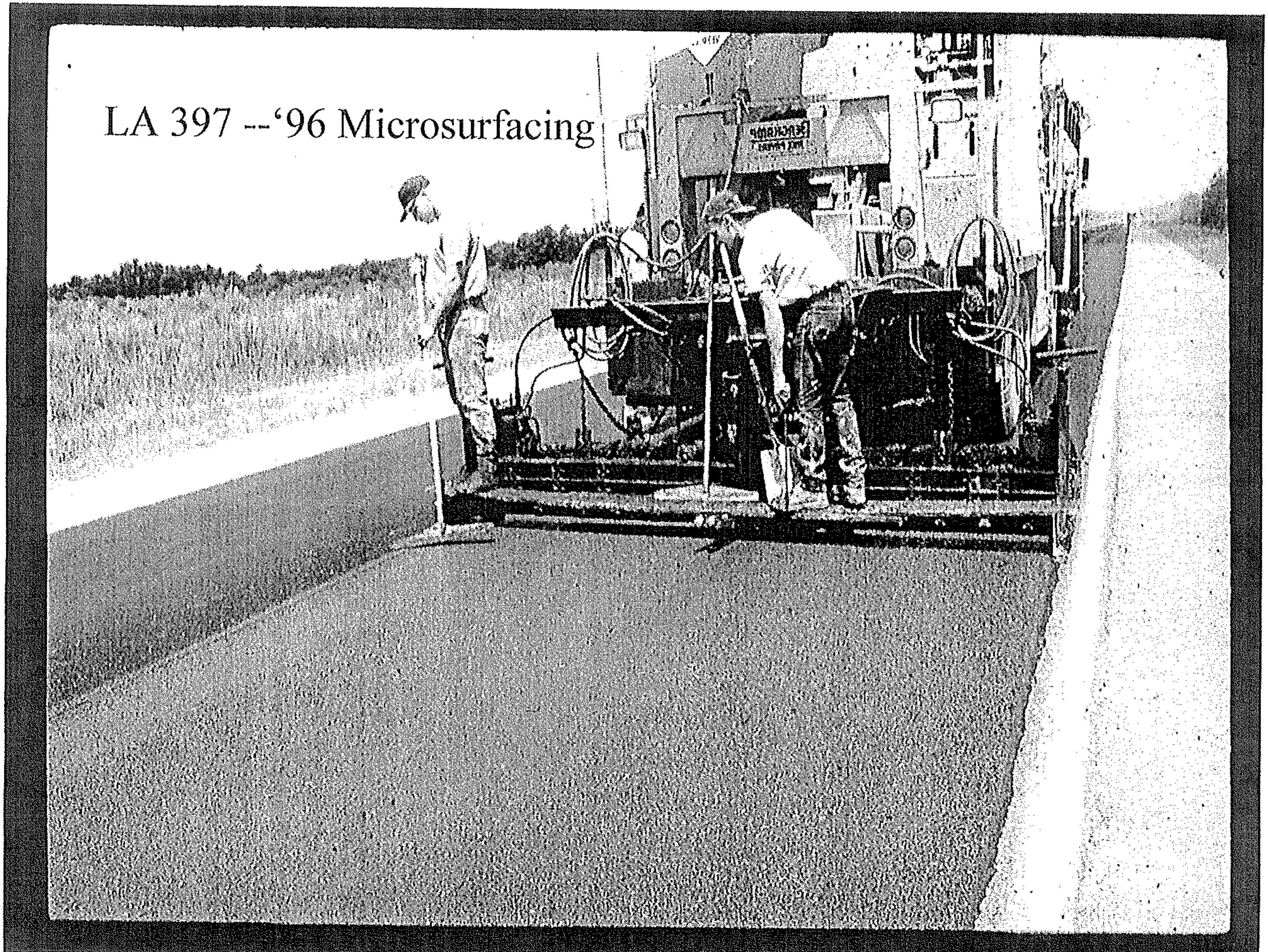


Table 8.1: Pavement Condition Index data on micro-surface projects

DIST	PROJ_NO	RTE	LENG	PTYPE	ADT	AGE3	TOP3	PCI3	AGE4	TOP4	PCI4	AGE5	TOP5	PCI5	AGE6	TOP6	PCI6
2	018-01-0028	US11	5.88	1	3814	24	14	88	38	14	86	48	19	84	60	16	82
2	148-01-0023	LA47	1.48	2	21071	24	10	50	36	10	50	46	11	88	.	.	.
2	410-02-0014	LA428	1.46	2	84041	25	10	80	38	14	85	50	17	83	64	17	83
2	410-01-0028	LA428	1.11	2	8281	26	10	80	38	14	88	50	17	83	64	17	83
2	828-38-0007	LA3018	1.82	1	3241	10	6	54	22	6	92	34	14	88	48	14	85
2	424-08-0023	US90	3.80	1	6077	10	6	92	22	10	90	34	13	87	48	13	87
2	855-04-0061	LA855	2.71	1	5506	24	7	83	35	10	80	48	12	88	61	15	85
3	828-12-0011	LA338	2.57	1	14566	6	8	93	18	10	90	30	14	88	41	14	88
3	380-04-0012	LA103	2.20	1	6037	17	14	66	30	18	82	42	21	73	53	25	73
4	010-05-0025	US71	5.18	1	1833	23	20	80	40	20	80	62	20	80	63	30	80
5	051-04-0015	LA17	2.38	1	3576	6	5	95	23	6	94	35	8	92	48	8	92
5	071-01-0022	LA137	7.12	2	3001	24	5	99	41	8	94	53	8	94	64	8	82
5	451-07-0045	I20	8.48	2	20307	.	.	.	27	8	92	39	8	92	50	8	83
5	058-02-0018	LA33	5.72	1	4388	.	.	.	22	11	88	34	11	88	45	11	85
7	200-01-0002	LA104	4.70	1	789	10	8	81	23	10	90	35	10	90	48	10	90
7	193-31-0022	LA397	5.12	1	4241	25	5	95	38	5	95	51	5	95	62	8	92
8	015-03-0021	US165	8.71	1	7588	21	18	86	38	15	85	50	18	84	61	16	84
8	025-02-0031	US171	5.28	1	7974	.	.	.	38	8	91	51	9	91	62	10	82
58	028-03-0028	US65	2.59	1	7821	23	7	93	40	7	93	52	.	.	.	.	.
58	022-08-0042	US84	1.38	1	6843	.	.	.	38	18	82	51	20	80	62	20	80
61	080-02-0028	LA67	4.55	1	5488	28	6	92	40	10	90	52	10	90	62	10	90
62	280-07-0018	LA43	6.84	1	3818	27	15	66	35	30	70	51	24	78	61	24	78
62	281-03-0018	LA22	5.12	1	7883	27	14	88	38	15	85	51	15	86	61	17	83
62	848-15-0005	LA3188	2.11	1	8800	26	11	85	38	11	88	48	11	89	62	18	84

Table 8.2:Individual distress deduct points for micro-surface projects

DIST	PROJ_NO	RTE	LENG	ADT	LCRACK6	ACRACK6	BLEED6	RUT6	ROUGH6	AGE6	PCI6
2	018-01-0028	US11	5.88	3814	8.6	0.10	0.1	1	8	60	82
2	148-01-0023	LA47	1.48	21071	.	.	.	.	.	.	.
2	410-02-0014	LA428	1.86	84041	12.0	0.15	0.1	1	3	64	83
2	410-01-0026	LA428	1.11	8281	12.0	0.15	0.1	1	3	64	83
2	828-38-0007	LA3018	1.82	3241	3.6	0.15	0.1	1	3	48	88
2	424-08-0023	US90	3.80	6077	3.2	1.20	3.8	1	3	48	87
3	855-04-0061	LA855	2.71	5506	3.2	1.20	0.1	3	3	61	85
3	828-12-0011	LA338	2.57	14568	1.8	0.15	8.4	3	3	41	88
3	380-04-0012	LA103	2.20	6037	12.0	1.20	3.8	1	3	53	78
4	010-05-0025	US71	5.18	1833	8.8	0.15	0.1	1	8	63	80
5	051-04-0015	LA17	2.38	3578	3.2	0.15	0.1	1	3	46	82
5	071-01-0022	LA137	7.12	3001	3.2	0.15	0.1	1	3	64	82
5	451-07-0045	I20	6.48	20307	0.2	0.15	0.1	1	3	50	92
5	058-02-0018	LA33	5.72	4388	4.0	3.00	0.1	1	3	45	85
7	200-01-0002	LA104	4.70	789	4.0	1.20	0.1	1	3	48	90
7	193-31-0022	LA397	5.12	4241	3.2	0.15	0.1	1	3	62	92
8	015-03-0021	US165	8.71	7586	8.6	1.20	0.1	1	3	61	84
8	025-02-0031	US171	5.28	7874	13.0	1.20	0.1	1	3	62	82
58	028-03-0028	US65	2.59	7821	.	.	.	.	.	.	.
58	022-08-0042	US84	1.38	6843	12.0	1.20	0.1	3	3	62	80
61	080-02-0025	LA67	4.55	5488	4.0	0.15	0.1	1	3	62	80
62	280-07-0018	LA43	6.84	3818	12.0	1.20	0.1	1	8	61	78
62	281-03-0018	LA22	5.12	7883	12.0	0.15	0.1	1	3	61	83
62	848-15-0005	LA3188	2.11	8800	3.2	0.15	3.8	3	3	62	84

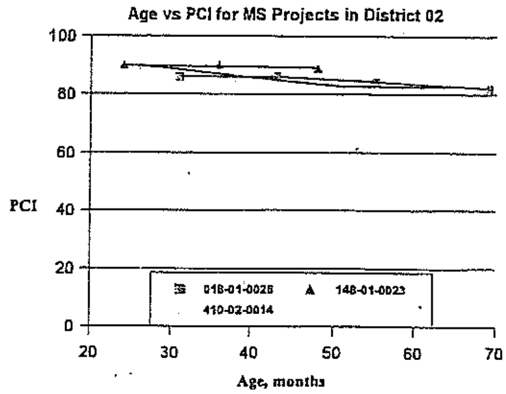


Figure 8.1a: Age vs PCI of micro-surface projects in District 02

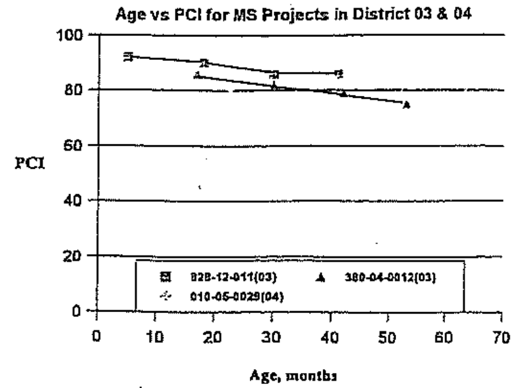


Figure 8.1c: Age vs PCI of micro-surface projects in District 03 & 04

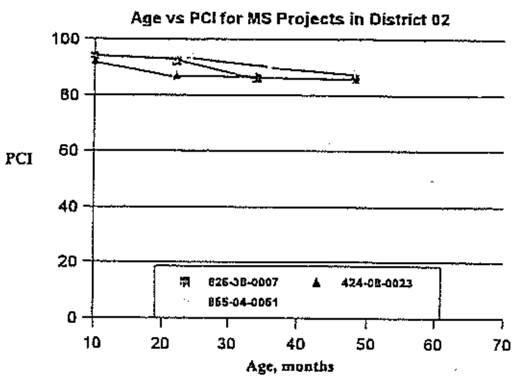


Figure 8.1b: Age vs PCI of micro-surface projects in District 02

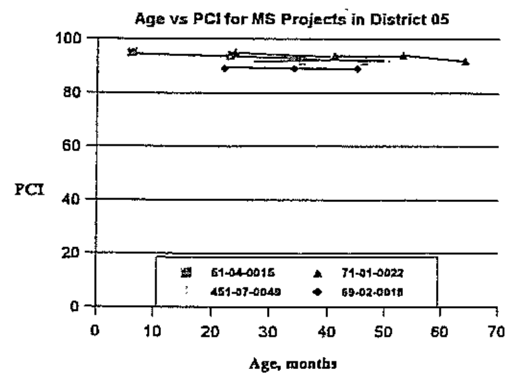


Figure 8.1d: Age vs PCI of micro-surface projects in District 05

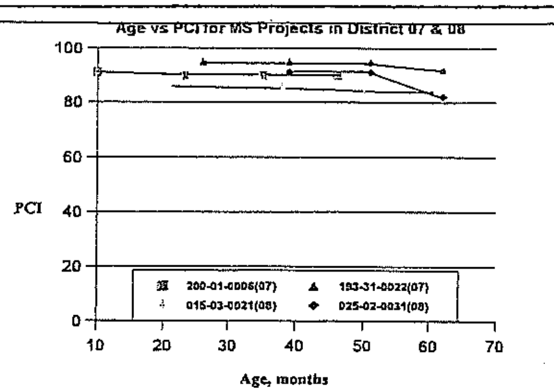


Figure 8.1e: Age vs PCI of micro-surface projects in District 07 & 08

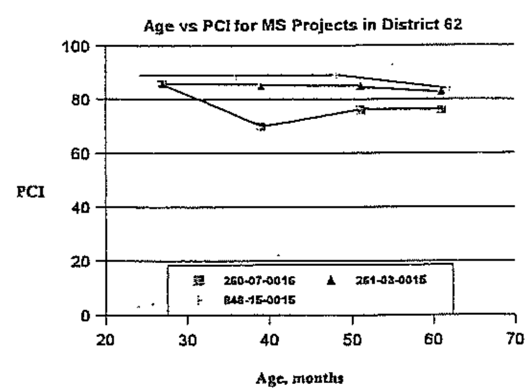


Figure 8.1g: Age vs PCI of micro-surface projects in District 62

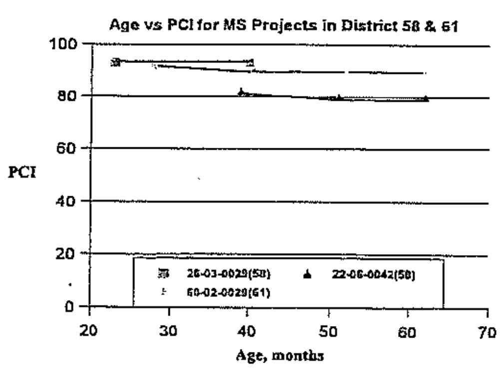


Figure 8.1f: Age vs PCI of micro-surface projects in District 58 & 61

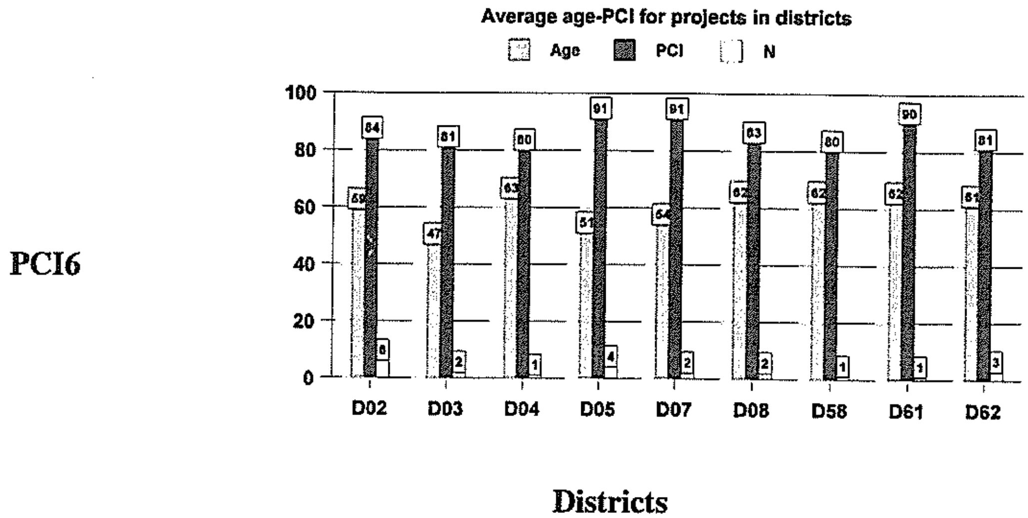
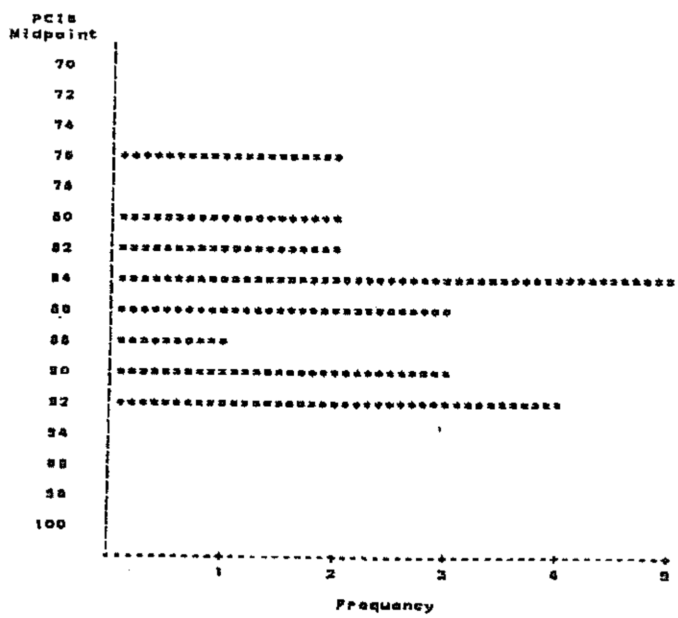


Figure 8.2: Time (age) -Performance (PCI) relationship of micro-surface projects in districts



PCI6 Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
70	0	0	0.00	0.00
72	0	0	0.00	0.00
74	0	0	0.00	0.00
76	2	2	9.09	9.09
78	0	2	0.00	9.09
80	2	4	9.09	18.18
82	2	6	9.09	27.27
84	5	11	22.73	50.00
86	3	14	13.64	63.64
88	1	15	4.55	68.18
90	3	18	13.64	81.82
92	4	22	18.18	100.00
94	0	22	0.00	100.00
96	0	22	0.00	100.00
98	0	22	0.00	100.00
100	0	22	0.00	100.00

Figure 8.3: Frequency distribution of PCI's

Effect of Pretreatment Pavement Condition on Performance

An analysis similar to the one for chip seal sections revealed a similar undefined trend. This is not surprising since most of the sections are still in the upper PCI range. The two sections in the 70s (tables 8.3 and 8.4) also failed to show any definitive trend. Using the guidelines of table 7.5 on page 26, the condition rating assigned to each section is shown in table B2 in Appendix B.

Effect of Other Variables on Performance

Figure 8.4 shows the effect of some of the other variables on PCI. Only the variable thickness exhibits a statistical difference (at 0.05 level) in the PCI at the two levels shown.

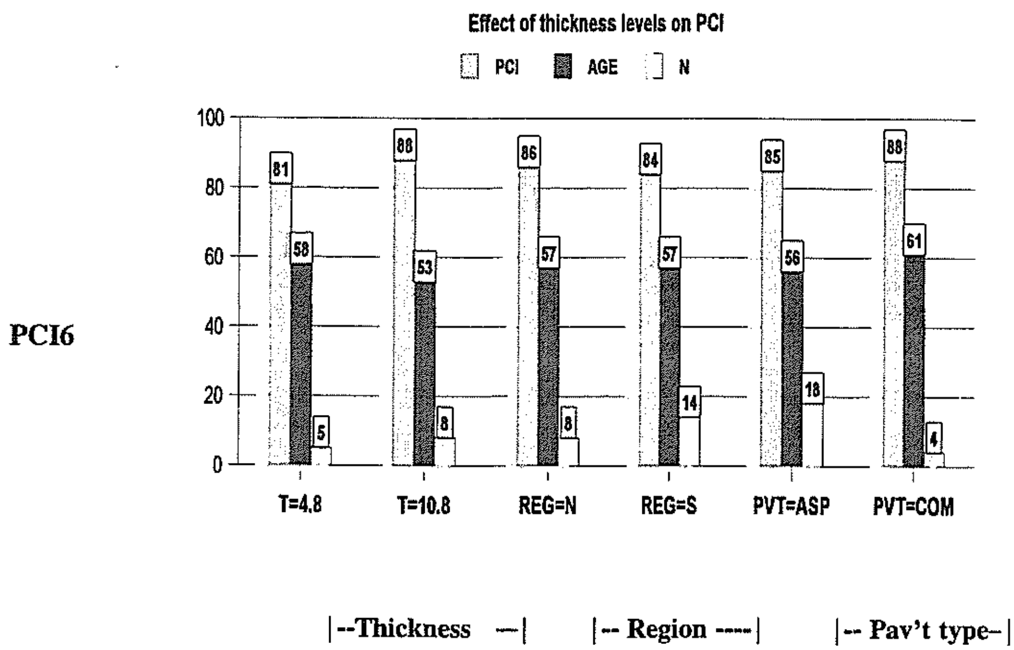


Figure 8.4: Effect of levels of variables shown on performance

Effect on Rutting

As noted earlier, micro-surfacing has been effectively used for filling ruts and for restoring the friction numbers to acceptable and safe values. Figure 8.5 presents the ARAN data on rutting before and after treatment. As was the case with chip seals, the period between the two ARAN measurements was three years. Individual data on rutting is listed in table 8.4. Notice that only three projects show rut measurements that can be considered marginally critical at best.

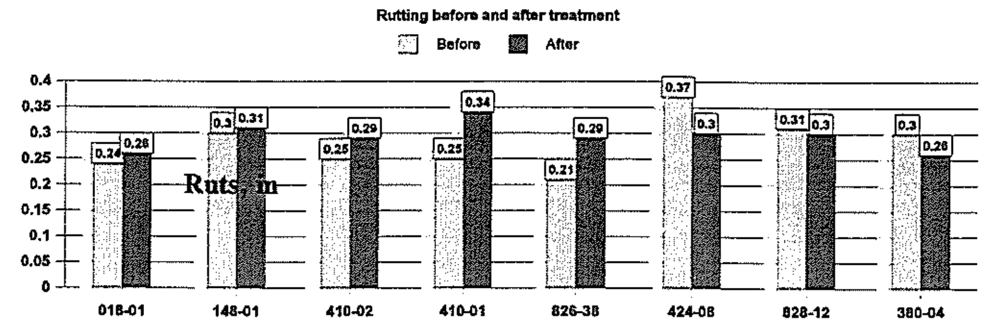
Table 8.3: ARAN random cracking and roughness data on micro-surface projects

DIST	PROJ_NO	RTE	LENG	ADT	AGE1	IRI1	RCRACKL1	RCRACKM1	RCRACKH1	AGE2	IRI2	RCRACKL2	RCRACKM2	RCRACKH2	AGE6	PCI6
2	018-01-0026	US11	5.86	3614	-5	174	0	3946	389	28	149	187	12	0	69	82
2	148-01-0023	LA47	1.45	21071	-5	186	0	3327	500	28	119	374	7	0	.	.
2	410-02-0014	LA428	1.85	64041	-4	182	0	305	1184	30	165	411	191	0	64	83
2	410-01-0026	LA428	1.11	8291	-4	126	528	953	36	30	156	85	130	0	64	83
2	826-38-0007	LA3018	1.62	3241	-20	150	0	1007	575	15	149	0	0	0	48	86
2	424-08-0023	US90	3.60	8077	-20	179	0	2342	133	14	141	76	0	0	48	87
2	855-04-0051	LA859	2.71	5505	.	.	.	.	.	.	.	.	.	.	61	85
3	828-12-0011	LA339	2.57	14566	-25	138	16	48	29	9	107	19	1.	0	41	86
3	380-04-0012	LA103	2.20	5037	-12	171	1	0	154	21	137	776	3	0	53	75
4	010-05-0029	US71	5.16	1833	.	.	.	.	.	.	.	.	.	.	63	80
5	051-04-0015	LA17	2.39	3575	-20	137	0	0	0	4	88	19	1	0	46	92
5	071-01-0022	LA137	7.12	3001	-4	88	475	13	3	31	79	67	17	0	64	92
5	451-07-0049	I20	6.48	20307	-16	84	5	350	0	8	82	136	0	0	50	92
5	069-02-0018	LA33	5.72	4388	-21	144	0	1760	0	3	121	142	46	57	45	89
7	200-01-0002	LA104	4.70	756	-20	131	144	1025	0	13	99	502	2	0	46	90
7	193-31-0022	LA397	5.12	4241	-4	107	6	13	0	30	70	64	3	0	62	92
8	015-03-0021	US165	6.71	7588	.	.	.	.	.	.	.	.	.	.	61	84
8	025-02-0031	US171	5.26	7974	-9	92	39	404	0	18	82	207	193	2	62	82
58	026-03-0029	US85	2.59	7821	-2	124	133	0	465	21	105	20	0	0	.	.
58	022-06-0042	US84	1.35	6583	-4	109	252	258	0	20	174	53	1	0	62	80
61	060-02-0029	LA67	4.55	9866	.	.	.	.	.	.	.	.	.	.	62	90
62	260-07-0016	LA43	4.94	3816	-4	134	0	1674	178	30	115	818	20	1	61	76
62	281-03-0015	LA22	5.12	7693	-4	113	841	880	0	31	147	111	109	0	61	83
62	848-15-0005	LA3188	2.11	9800	-7	157	259	529	0	27	131	137	2	0	62	84

Table 8.4: ARAN alligator cracking and rutting data on micro-surface projects

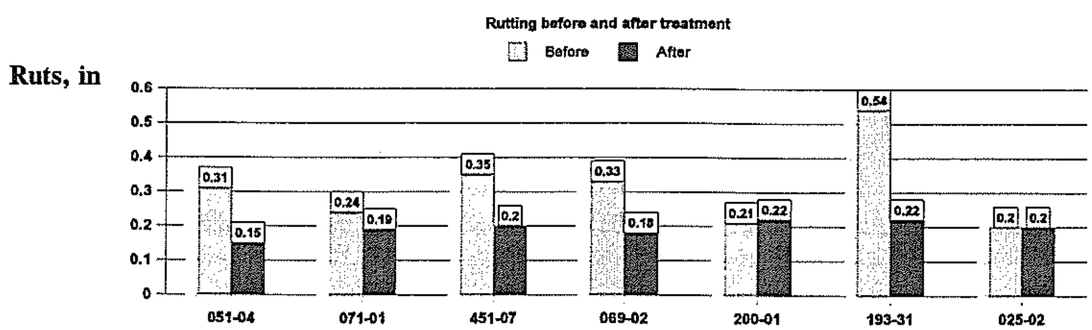
DIST	PROJ_NO	RTE	LENG	ADT	AGE1	RUT1	ACRACKL1	ACRACKM1	ACRACKH1	AGE2	RUT2	ACRACKL2	ACRACKM2	ACRACKH2	AGE6	PCI6
2	018-01-0026	US11	5.86	3814	-5	0.24	0	451	51	28	0.26	0	0	0	69	82
2	148-01-0023	LA47	1.45	21071	-5	0.30	0	1206	217	28	0.31	0	0	0	.	.
2	410-02-0014	LA428	1.85	64041	-4	0.25	0	0	0	30	0.29	2	8	0	64	83
2	410-01-0026	LA428	1.11	8291	-4	0.25	0	0	0	30	0.34	0	0	0	64	83
2	828-38-0007	LA3018	1.62	3241	-20	0.21	0	0	0	15	0.29	39	1	0	48	86
2	424-08-0023	US90	3.60	8077	-20	0.37	0	579	27	14	0.30	1	0	0	48	87
2	855-04-0051	LA859	2.71	5506	.	.	.	.	.	.	.	.	.	.	61	85
3	828-12-0011	LA339	2.57	14566	-25	0.31	54	1034	241	9	0.30	1	1	0	41	86
3	380-04-0012	LA103	2.20	5037	-12	0.30	0	264	138	21	0.26	0	0	0	53	75
4	010-05-0029	US71	5.16	1833	.	.	.	.	.	.	.	.	.	.	63	80
5	051-04-0015	LA17	2.38	3575	-20	0.31	0	1143	78	4	0.15	0	0	0	46	92
5	071-01-0022	LA137	7.12	3001	-4	0.24	110	0	8	31	0.19	0	0	0	64	92
5	451-07-0049	I20	6.48	20307	-16	0.35	159	69	9	8	0.20	0	0	0	50	92
5	069-02-0018	LA33	5.72	4388	-21	0.33	571	0	0	3	0.18	0	1	1	45	89
7	200-01-0002	LA104	4.70	756	-20	0.21	39	552	1	13	0.22	0	0	0	46	90
7	193-31-0022	LA397	5.12	4241	-4	0.54	79	38	0	30	0.22	70	0	0	62	92
8	015-03-0021	US166	6.71	7588	.	.	.	.	.	.	.	.	.	.	61	84
8	025-02-0031	US171	5.26	7974	-9	0.20	0	31	0	18	0.20	2	0	0	62	82
58	026-03-0029	US65	2.59	7821	-2	0.50	387	0	0	21	0.20	0	0	0	.	.
58	022-06-0042	US84	1.35	6583	-4	0.50	334	344	0	20	0.27	0	0	0	62	80
61	060-02-0029	LA67	4.55	9866	.	.	.	.	.	.	.	.	.	.	62	90
62	260-07-0016	LA43	4.94	3816	-4	0.19	0	85	5	30	0.24	5	1	0	61	76
62	261-03-0015	LA22	5.12	7693	-4	0.26	0	0	0	31	0.22	0	1	0	61	83
62	848-15-0005	LA3188	2.11	9800	-7	0.36	96	323	0	27	0.37	0	0	0	62	84

Most of the projects show preconstruction ruts around 0.30 inches. Whether rutting or a low friction number was the deciding factor for micro-surfacing these projects cannot be ascertained due to absence of pretreatment friction numbers on these projects. It also raises the question of whether the appropriate projects were selected for micro-surfacing.



|------------------------------ Dist 02 ------------------------------| | -- Dist 03 -----|

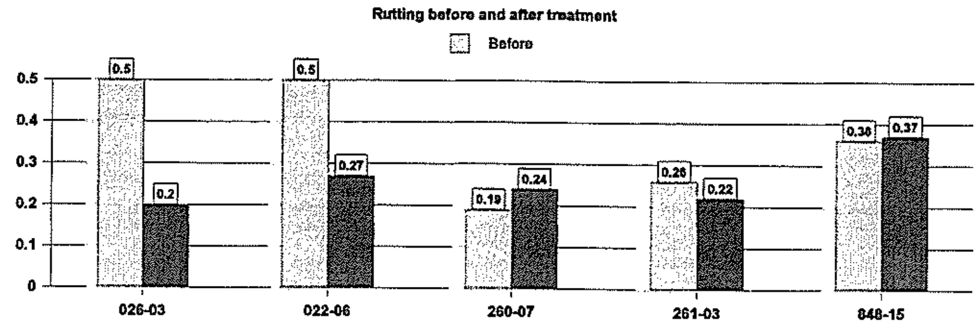
Figure 8.5a: Rutting before and after treatment application



|--------------- Dist 05 ---------------------| |-------Dist 07 --| |Dist 08|

Figure 8.5b: Rutting before and after treatment application

Ruts, in



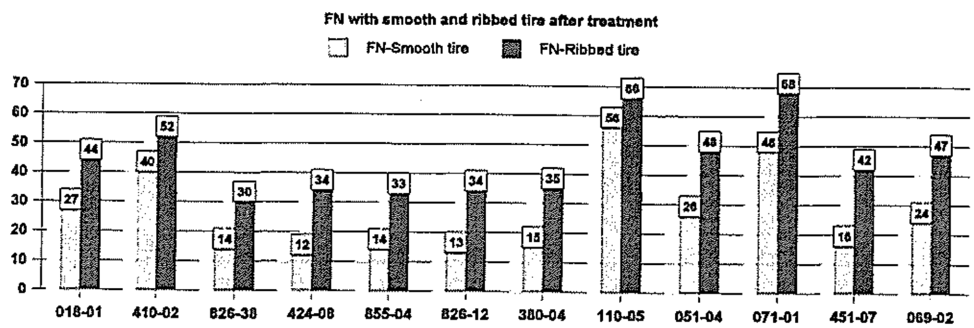
| ---------Dist 58 ----------| |----- ------------- -Dist 62 --------------|

Figure 8.5c: Rutting before and after treatment application

Effect on Friction Numbers

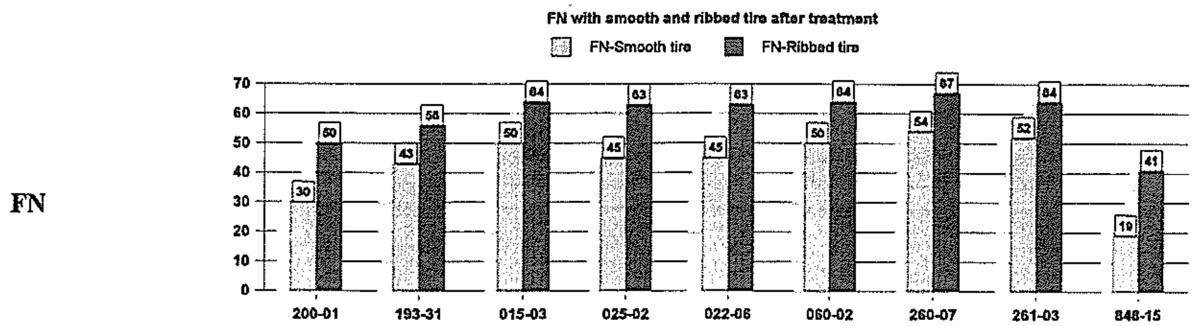
Figures 8.6a and 8.6b are plots of friction numbers (FN) for the projects using smooth and ribbed tire. Data on friction numbers is listed in Table 8.5.

FN



| ---------------Dist 02 -----------| |-Dist 03-| |D 04| |----------Dist 05 ---------|

Figure 8.6a: Friction Numbers on projects in District 02, 03, 04 & 05



| -Dist 07 —| |--Dist 08---| |D 58| |D 61| |---------Dist 62 --------|

Figure 8.6b: Friction Numbers on projects in District 07, 08, 58, 61 & 62

Almost half the project sections have smooth tire FNs of less than 30 with seven of these in the teens. Such low numbers are generally indicative of a lack of adequate macro-texture, which increases the hydroplaning potential. Sections with low smooth tire FN (teens) also show low FN's (low 30s) for ribbed tire. A review of the aggregate type used on most of these projects revealed that the low FNs may have been a result of limestone aggregate. The type and source of aggregates used on these projects is shown in Table B3 in Appendix B. The high numbers were from the polish resistant sandstone aggregates (11). These aggregates have sharp and angular faces and provide a flat age gradient. Most of these sandstone projects are more than four years old.

Table 8.5: DOTD Friction Numbers (FN) and rutting data on micro-surfacing prpjects

DIST	PROJ_NO	RTE	LENG	ADT	THICK	COST	AVG_RUT	AVG_IRI	FN_S	FN_R	AGE6	PCI6
2	018-01-0026	US11	5.36	3614	5.35	2.29	0.29	150	26.9	43.6	69	82
2	148-01-0023	LA47	1.45	21071	11.10	4.85	.		.	.	.	.
2	410-02-0014	LA428	1.85	64041	[illegible]	3.34	.	.	39.5	51.9	54	83
2	410-01-0026	LA428	1.11	8291	1[illegible].37	3.48	.		.	.	64	33
2	826-38-0007	LA3018	1.62	3241	1[illegible].36	3.94	.		13.5	29.5	48	86
2	424-08-0023	US90	3.60	8077	5.50	3.60	0.17	141	11.9	34.2	48	87
2	855-04-0051	LA859	2.71	5505	.	2.14	0.15	93	14.1	32.8	61	85
3	828-12-0011	LA339	2.57	14566	15.79	2.62	0.39	113	12.3	33.5	41	86
3	380-04-0012	LA103	2.20	5037	3.57	3.75	0.11	134	14.6	35.0	53	75
4	010-05-0025	US71	5.16	1833	.	2.40	.	.	55.5	65.5	63	80
5	051-04-0015	LA17	2.39	3575	6.05	3.68	.	.	26.4	48.0	46	92
[illegible]	071-01-0022	LA137	7.12	3001	8.70	1.71	.	.	47.3	68.4	64	92
5	451-07-0049	I20	5.48	20307	19.70	2.54	.	.	15.8	41.7	50	92
5	069-02-0018	LA33	5.72	4388	8.21	.	.	.	24.1	46.6	45	89
7	200-01-0002	LA104	4.70	756	.	.	0.26	105	29.7	50.0	46	90
7	193-31-0022	LA397	5.12	4241	.	3.68	0.25	67	43.4	56.1	62	92
8	015-03-0021	US165	6.71	7588		2.10	0.16	105	49.9	63.5	61	84
8	025-02-0031	US171	5.26	7974		2.56	0.22	83	45.4	63.4	62	82
58	075-03-0029	US65	2.59	7821		2.55	.	.	.	.	.	.
58	072-06-0042	US84	1.35	6583	.	2.85	0.33	110	45.2	62.7	62	80
61	080-02-0025	LA67	4.55	9866	.	2.80	0.23	97	49.6	[illegible]	62	90
62	260-07-0016	LA43	4.94	3816	3.64	2.50	0.17	118	54.0	[illegible]	61	76
62	261-03-0015	LA22	5.12	7693	6.00	2.58	0.12	90	51.8	[illegible]	61	83
62	848-15-0005	LA3188	2.11	9800		2.36	0.17	122	19.1	40.9	62	84

Miscellaneous Analysis

ARAN Before and After Survey Data Evaluation

This analysis on micro-surfacing projects is similar to the one presented for chip seal projects in chapter 7. The ARAN data on the distresses are listed in tables 8.3 and 8.4. The before and after evaluation of these distresses are plotted in figures 8.7 and 8.8. As with chip seal data, only projects constructed within six months of construction are included in the plots.

The charts show that in most cases there is a substantial reduction in the magnitude and severity of the measured distress. As was evident on chip seal projects, there is a marked reduction in alligator cracking after the treatment. An increase in low severity random cracking after the treatment application similar to that noticed with the chip seal sections was indicated in some cases.

ARAN and Subjective Rating

Figures 8.9 and 8.10 show some of the relationships between subjective rating and measured rating. Figure 8.9 shows the relationship between the longitudinal/transverse cracking survey data of table 8.2 and random cracking as measured by ARAN and shown in table 8.3. The R^2 for this relationship is 0.49 and is significant at the 0.01 level ($F=13.57$). However, as with chip seal data, alligator cracking did not show any noticeable trend.

Visual Distress Rating (Bleeding) and Friction Numbers

The association of bleeding to FN is shown in figure 8.10. The R^2 for this relationship is 0.30, which is significant at the 0.01 level ($F=8.30$). The low friction numbers (30 and below) should be attributed to the type and/or source of aggregate used in the mix and not to bleeding since there was practically none. In essence, there is a confounding effect of aggregate on the friction number.

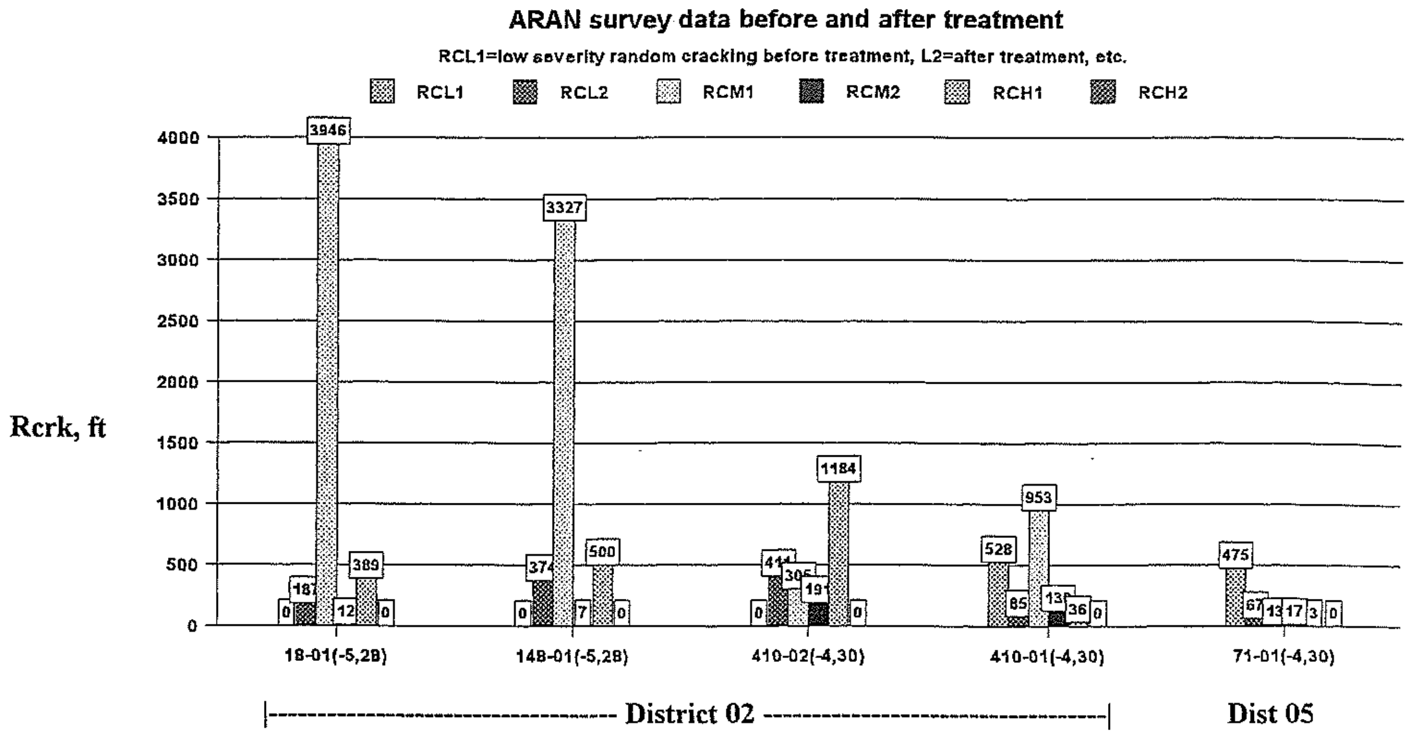


Figure 8.7a: Random cracking condition before and after micro-surface treatment

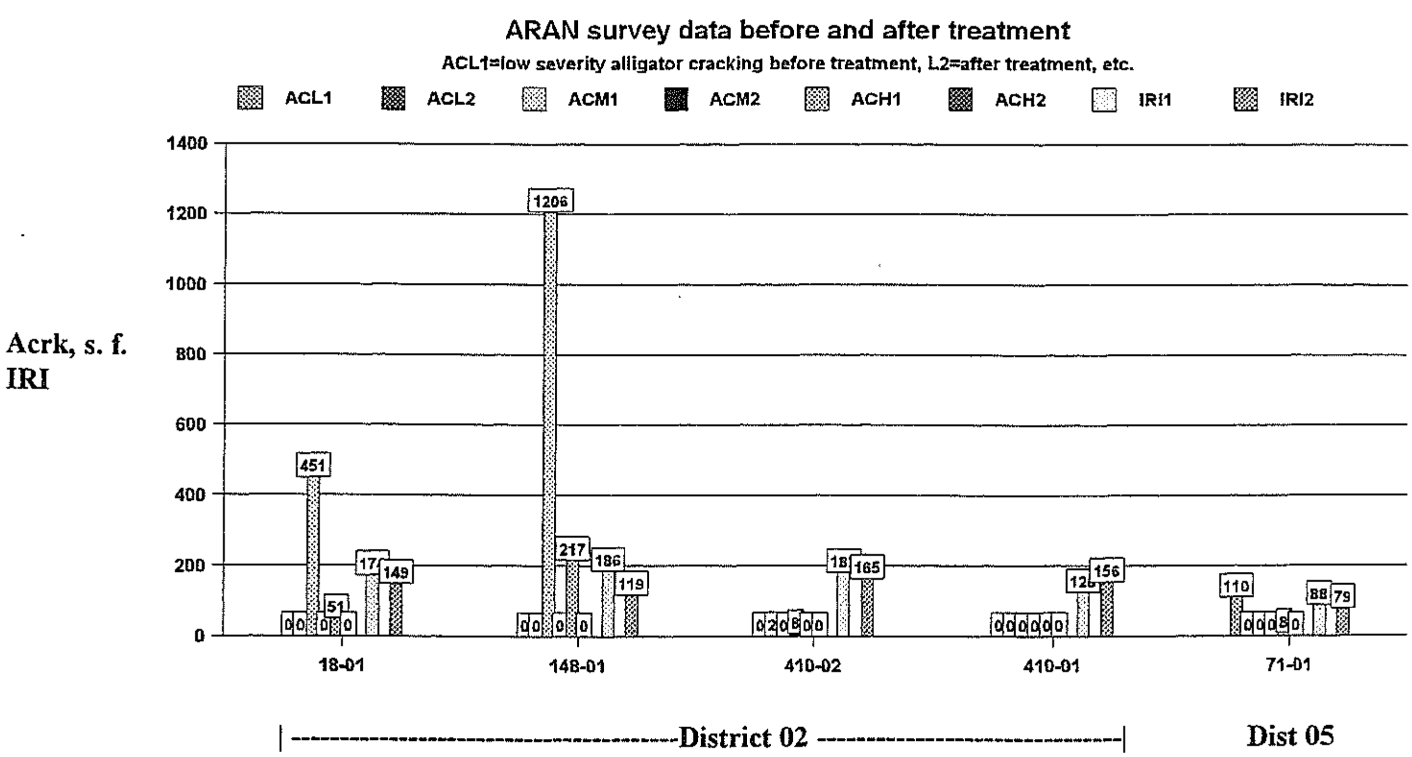


Figure 8.7b: Alligator cracking condition and IRI before and after micro-surfacetreatment

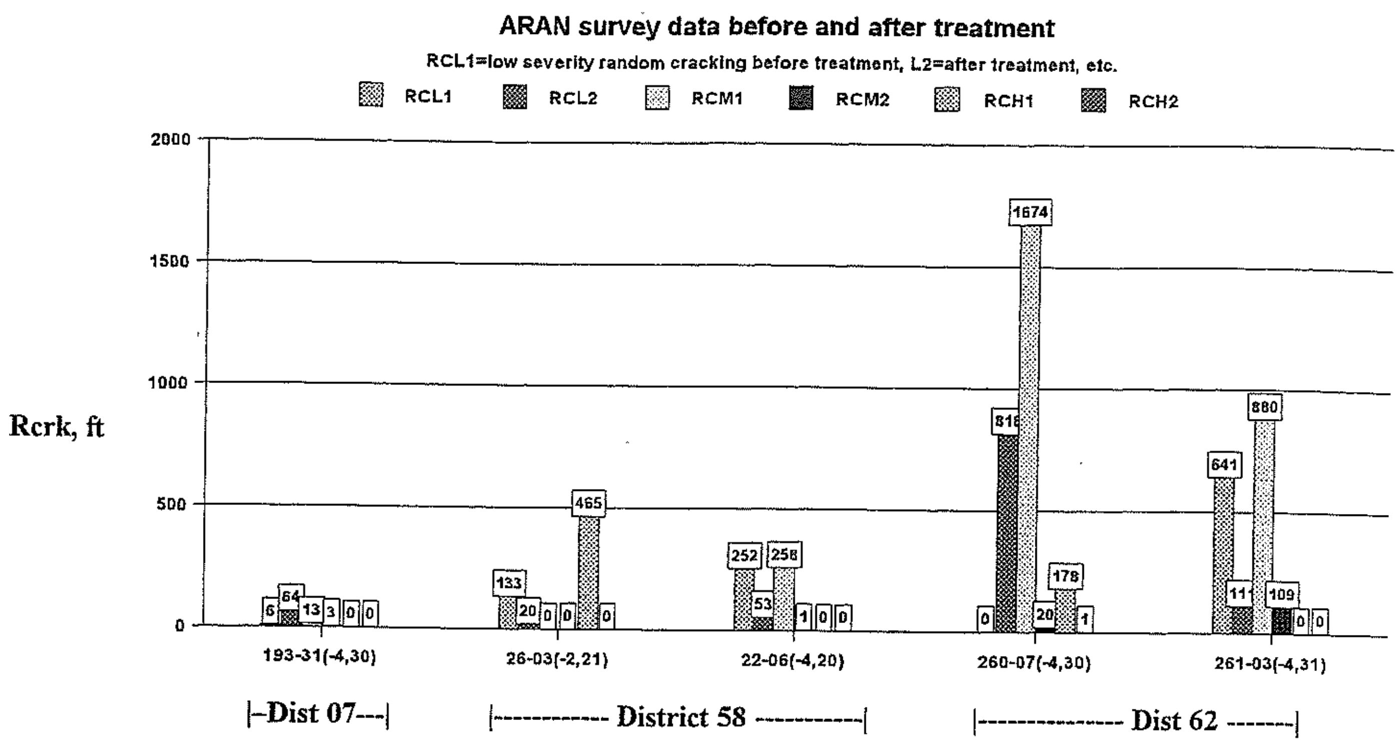


Figure 8.8a: Random cracking condition before and after micro-surface treatment

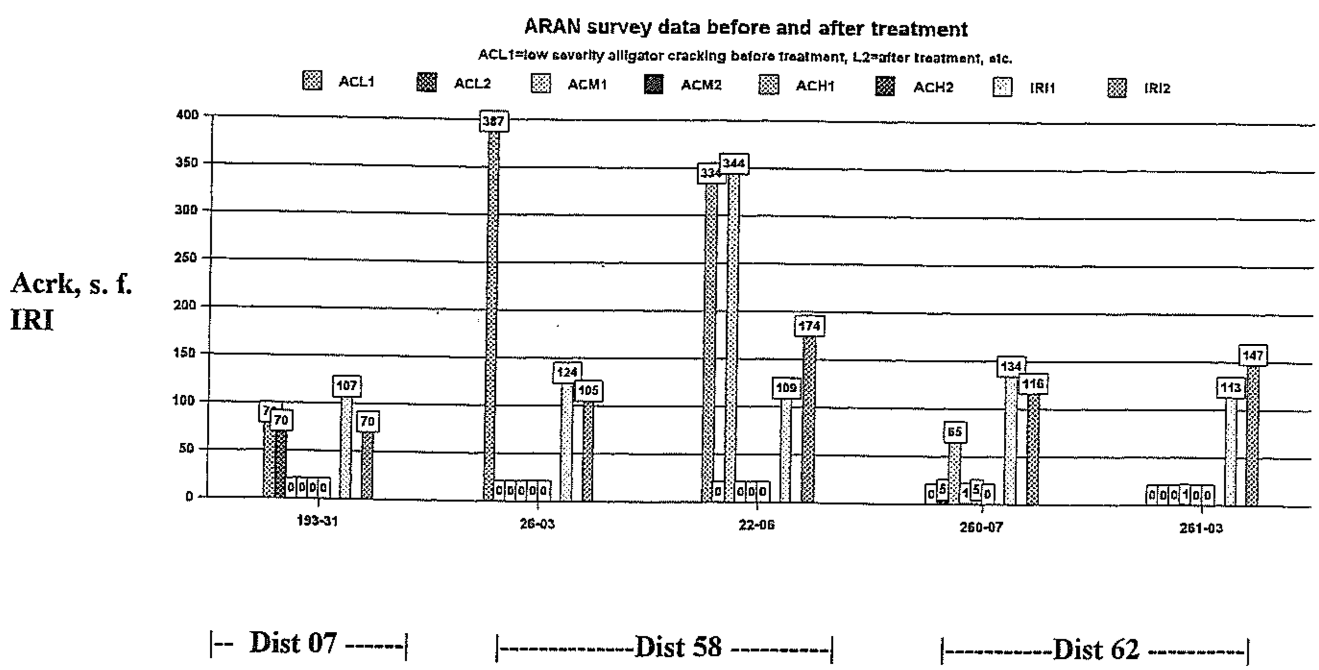


Figure 8.8b: Alligator cracking condition and IRI before and after micro-surface treatment

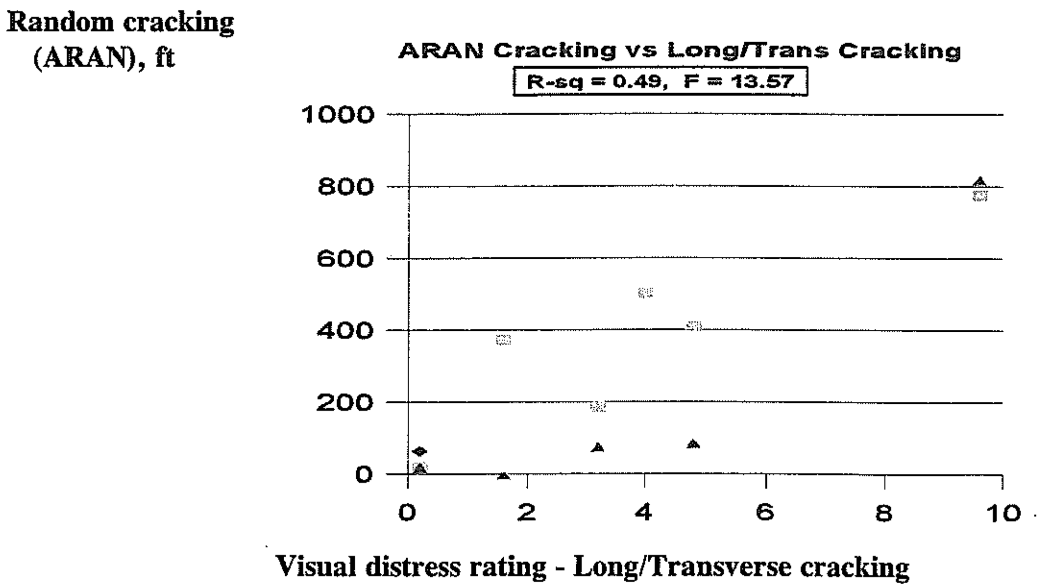


Figure 8.9: Relationship between visual distress and measured distress on cracking

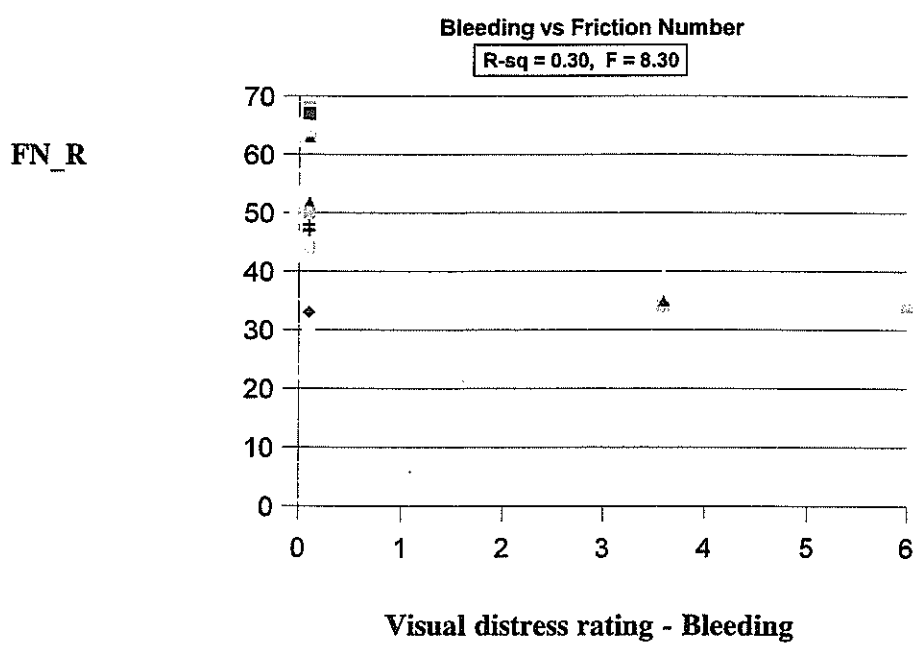


Figure 8.10: Relationship between bleeding and FN

Summary

Based on four condition surveys of 24 micro-surface sections, the analysis and evaluation discussed in this chapter can be summarized as follows:

- The median PCI of micro-surface sections is about 85 after 60 months of service. Likewise, almost all sections show a flat age-performance curve over a five-year period.

- Of the 24 sections, more than 80 percent are above 80 PCI. Only two sections show a PCI of less than 80. Two sections have received some form of rehabilitation. The rehabilitation may be due to low friction numbers since the PCI's were in the 80s and 90s.

- The effect of pretreatment pavement condition on performance was not evident from the ARAN cracking data . However, the before and after ARAN data indicate overall improvement in cracking and roughness distress due to micro-surfacing.

- Rutting did not seem to be the primary reason for the application of this treatment since most of the ruts prior to treatment were less than a half inch deep. However, projects that had average ruts of 0.5 inches or more prior to treatment did show substantial reduction after the treatment.

- Friction numbers for smooth tire are in low teens to low 30s on about half the projects. For ribbed tire, the numbers are in the low thirties. These numbers can be traced to limestone aggregate on the majority of the sections. Likewise, sandstone aggregate sections are in the 50s and 60s after almost four years of service.

- The subjective survey of various distresses provides information that relates to measured distress and can be used for routine rating of pavements.

9. COST-EFFECTIVENESS EVALUATION

Generally, a cost-effectiveness analysis is performed to determine the treatment of the least cost for a given set of conditions. For example, if a pavement section shows ruts that are less than 3/8 inch and cracking of low severity and moderate raveling and/or low skid numbers, one has several choices available to take corrective action. These may include thin overlay, slurry seal, chip seal, or micro-surfacing. Since all of these are considered very effective in correcting the stated distresses, their selection should be based on the cost of each treatment, which can vary considerably.

Cost-Effectiveness Evaluation

The approaches to determining cost-effectiveness can vary from a simple method, requiring minimum information on the input variable to a complex method, necessitating input on several economic variables. For example, life-costing is very complicated and requires input on inflation, interest rate, unit cost of treatment, analysis period, life of the treatment, etc., whereas, the equivalent annual cost (EAC), as a simple method (9, 12), requires input on unit cost and expected life of treatment. It is defined by the following equation:

$$\mathbf{EAC} = \frac{\textbf{Unit cost}}{\textbf{expected life of treatment}}$$

The unit cost can be the bid cost. However, before using this bid cost it should be ascertained whether the bid price includes items that are common to all projects across the state. For example, if a number of items are grouped under one bid on one project, the same grouping should be on other projects. If maintenance costs are incurred on the project during the service life of the treatment, they should be part of the unit cost. The cost of this activity could be associated with the routine maintenance function that is likely to prolong the life of the seal.

The expected life can be obtained from available historical data on the treatments or accumulated from a study such as the one discussed here. Geoffroy *(9)* has developed average cost and life data for chip seal and micro-surfacing treatments from those incurred by a number of states. For chip seal, the typical average is \$0.85/sq yd (\$1.02/m sq), while for micro-surfacing, the average cost is \$1.25/sq yd (\$1.50/m sq). The life expectancy is 4 to 6 years and 5 to 7 years for chip seal and micro-surfacing, respectively. Based on these values, a typical EAC is \$0.17/year *(12)*.

Cost-Effective Evaluation of Chip Seals

Table 9.1 lists the unit construction and maintenance cost and the Equivalent Annual Cost EAC for each chip seal project. Figure 9.1 is the frequency distribution of EAC. The maintenance cost reported in the tables represents the entire control section. This is because such costs are not reported by project but by control section, which may be only a portion of the total control section length.

The average statewide cost of a chip seal is about \$1.35/sq yd (\$1.61/m^2). This is about \$0.50/sq yd more than the national average of \$0.85/sq yd mentioned above. The maintenance cost is clustered around \$0.20/sq yd giving an average total cost of \$1.55/sq yd. Based on these values, the average EAC of the chip seals is about \$0.35. This is almost twice the annual reported in reference *12*. Even if the maintenance cost is excluded, the average EAC for projects is \$0.27 for a five-year life expectancy.

Although the life expectancy of most of the sections is unknown, the EAC varies from a low of \$0.25 per year to high of \$0.75 per year based on their current condition. Assuming a life of five years for all projects, the EAC varies from a low of \$0.22/year to a high of \$0.59/year. This wide variation in EAC is a result of project and/or regional variation in bid price and lack of accurate data on maintenance cost. There may be a need to develop a limiting value of this parameter to evaluate the effectiveness of chip seals.

Cost-Effective Evaluation of Micro-surface

The various cost data are listed in table 9.2. The frequency distribution of EAC for study projects/sections is shown in figure 9.2. In the table, the cost of micro-surfacing in the state varies considerably from a low of \$1.71/sq yd (\$2.05/sq m) to a high of \$4.85/sq yd (\$5.80/sq m). The average statewide construction cost is about \$2.93/sq yd (\$3.50/m^2). This is more than double the amount reported in reference *12*. The average maintenance cost is \$0.16/sq yd (\$0.19/sq m).

The average EAC is $0.68 with individual values varying from $0.34 to $1.31. The nationwide average *(12)* is around $0.21, which is almost one third the average of these study sections. Discounting the maintenance cost, the average EAC is about $0.49 assuming life expectancy of six years. Individually, for the same life expectancy and no maintenance cost, the cost varies from a low of $.28 to a high of $0.80.

Table 9.1: Equivalent Annual Cost (EAC) of Chip Seal Projects

DIST	PROJ_NO	CONST COST PER SQ YD	PROJECT LENGTH MILES	CONT_SEC LENGTH MILES	TOTAL MAINT COST	MAINT COST PER SQ YD	TOTAL COST	AGE YRS	CURRENT PCI	EQUIVALENT ANNUAL COST
3	235-01-0007	1.21	4.20	6.09	30800	0.36	1.57	5.25	47	0.30
3	393-03-0013	1.33	5.23	7.23	31000	0.30	1.63	5.25	50	0.31
3	385-04-0004	2.33	2.70	2.69	21000	0.60	2.93	3.92	90	0.75
3	203-01-0007	1.30	4.14	4.14	.	.	.	5.17	43	.
3	850-08-0008	1.31	2.64	2.64	18400	0.50	1.81	5.17	37	0.35
4	043-06-0020	1.32	7.49	14.46	88100	0.43	1.75	4.17	53	0.42
4	111-01-0016	1.30	7.92	7.92	4800	0.04	1.34	4.17	92	0.32
4	085-03-0013	1.85	6.26	8.65	37000	0.33	2.18	5.17	74	0.42
4	082-05-0006	1.19	7.22	7.22	16100	0.17	1.36	4.00	82	0.34
5	166-05-0005	1.09	4.99	5.67	30900	0.46	1.55	5.08	69	0.31
5	037-02-0032	1.41	9.00	14.36	69400	0.34	1.75	5.00	60	0.35
7	199-01-0006	1.08	7.43	7.43	900	0.01	1.09	3.92	78	0.28
7	031-08-0017	1.28	11.72	11.72	9000	0.05	1.33	3.92	76	0.34
7	382-04-0033	1.39	5.66	8.00	14600	0.13	1.52	4.33	79	0.35
7	193-02-0041	1.24	5.45	14.30	2700	0.01	1.25	4.33	85	0.29
7	193-03-0008	1.31	2.13	2.13	100	0.00	1.31	4.33	84	0.30
7	193-04-0008	1.18	6.24	6.24	300	0.00	1.18	4.33	84	0.27
7	196-01-0019	1.10	7.27	10.05	7800	0.06	1.16	3.92	85	0.30
7	193-05-0015	1.13	4.97	4.97	400	0.01	1.14	4.33	69	0.26
7	827-31-0003	1.44	1.89	1.89	1200	0.05	1.49	5.08	86	0.29
7	812-08-0003	1.57	2.33	2.33	3600	0.13	1.70	5.08	84	0.33
8	057-08-0012	1.93	3.57	3.75	3800	0.07	2.00	5.00	74	0.40
8	858-12-0001	0.95	2.80	2.80	.	.	.	3.58	84	.
8	365-01-0008	1.00	8.77	8.77	36700	0.32	1.32	3.42	88	0.39
58	143-05-0021	0.98	5.48	11.20	46300	0.35	1.33	3.50	75	0.38
58	143-06-0023	1.04	4.36	5.05	400	0.01	1.05	3.50	64	0.30
58	152-02-0008	1.30	2.29	2.29	500	0.02	1.32	5.17	72	0.25
58	039-04-0043	1.10	3.83	12.13	16100	0.09	1.19	4.00	74	0.30
58	173-01-0025	1.05	4.65	14.58	28900	0.14	1.19	3.50	89	0.34
58	036-04-0049	1.41	7.15	16.48	41300	0.19	1.60	4.00	76	0.40
58	051-03-0027	1.26	12.91	12.91	65400	0.36	1.62	5.17	82	0.31
61	863-02-0022	1.06	6.92	15.72	85500	0.46	1.52	4.42	83	0.34
61	804-28-0008	1.58	0.66	0.66	900	0.13	1.71	4.58	73	0.37
61	804-29-0009	1.37	0.76	0.76	1400	0.17	1.54	4.58	66	0.34
61	804-38-0006	1.40	3.65	3.65	21700	0.51	1.91	3.42	42	0.56
61	804-20-0003	1.98	1.29	1.29	5600	0.37	2.35	4.58	52	0.51
62	859-09-0017	1.13	8.83	10.70	3400	0.03	1.16	3.50	70	0.33
62	278-05-0005	1.08	4.56	4.56	2700	0.05	1.13	3.50	72	0.32
62	260-09-0005	1.39	3.80	9.93	3100	0.02	1.41	4.92	55	0.29
62	260-06-0009	1.69	3.69	4.87	17100	0.25	1.94	4.92	76	0.39

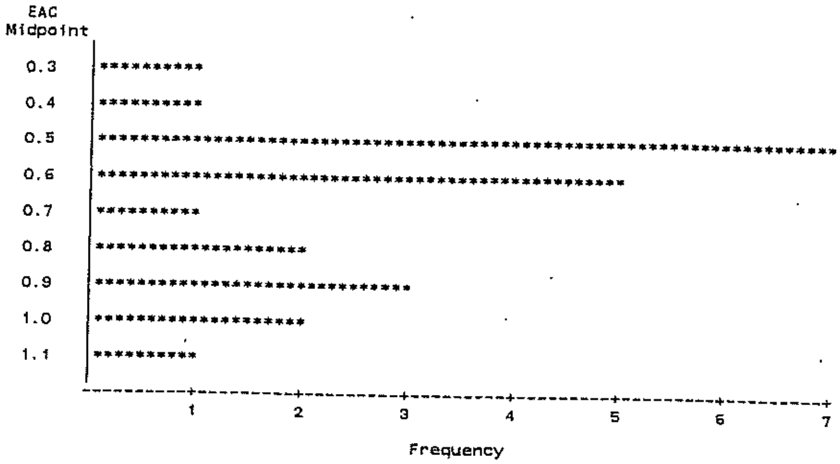
```
EAC                                                                                                     Cum.               Cum.
Midpoint                                                                                         Freq   Freq   Percent   Percent
0.20  |                                                                                            0      0      0.00      0.00
0.25  |***************                                                                             3      3      7.89      7.89
0.30  |**********************************************************************                     14     17     36.84     44.74
0.35  |*******************************************************                                    11     28     28.95     73.68
0.40  |***********************************                                                         7     35     18.42     92.11
0.45  |                                                                                            0     35      0.00     92.11
0.50  |*****                                                                                       1     36      2.63     94.74
0.55  |*****                                                                                       1     37      2.63     97.37
0.60  |                                                                                            0     37      0.00     97.37
0.65  |                                                                                            0     37      0.00     97.37
0.70  |                                                                                            0     37      0.00     97.37
0.75  |*****                                                                                       1     38      2.63    100.00
0.80  |                                                                                            0     38      0.00    100.00
      |
  ----+----+----+----+----+----+----+----+----+----+----+----+----+----+
       1    2    3    4    5    6    7    8    9   10   11   12   13   14

                               Frequency
```

Figure 9.1: Frequency distribution of EAC for chip seal projects

Table 9.2: Equivalent Annual Cost (EAC) of Micro-Surface Projects

DIST	PROJ_NO	CONST COST PER SQ YD	PROJECT LENGTH MILES	CONT_SEC LENGTH MILES	TOTAL MAINT COST	MAINT COST PER SQ YD	TOTAL COST	AGE YRS	CURRENT PCI	EQUIVALENT ANNUAL COST
2	018-01-0026	2.29	5.86	5.86	31100	0.41	2.70	5.75	82	0.47
2	148-01-0023	4.85	1.45	3.36	38700	0.41	5.26	4.00	89	1.31
2	410-02-0014	3.34	1.85	1.85	6100	0.12	3.46	5.33	83	0.65
2	410-01-0026	3.48	1.11	2.80	14300	0.18	3.66	5.33	83	0.69
2	826-38-0007	3.94	1.62	1.62	2800	0.12	4.06	4.00	86	1.02
2	424-08-0023	3.60	3.60	16.26	31700	0.07	3.67	4.00	87	0.92
2	855-04-0051	2.14	2.71	5.18	7200	0.10	2.24	5.08	85	0.44
3	828-12-0011	2.62	2.57	5.59	12500	0.16	2.78	3.42	86	0.81
3	380-04-0012	3.75	2.20	5.40	13900	0.20	3.95	4.42	75	0.89
4	010-05-0029	2.40	5.16	11.17	47000	0.30	2.70	5.25	80	0.51
5	051-04-0015	3.68	2.39	3.62	3600	0.07	3.75	3.83	92	0.98
5	071-01-0022	1.71	7.12	8.71	20000	0.08	1.79	5.33	92	0.34
5	451-07-0049	2.54	6.48	27.40	27500	0.04	2.58	4.17	92	0.62
5	069-02-0018	3.24	5.72	9.03	12200	0.10	3.34	3.75	89	0.89
7	200-01-0002	.	4.70	4.70	500	0.01	.	3.83	90	.
7	193-31-0022	3.68	5.12	5.71	19100	0.24	3.92	5.17	92	0.76
8	015-03-0021	2.10	6.71	6.21	66400	0.38	2.48	5.08	84	0.49
8	025-02-0031	2.56	5.26	17.98	66100	0.17	2.73	5.17	82	0.53
58	026-03-0029	2.55	2.59	6.71	16500	0.09	2.64	4.33	93	0.61
58	022-06-0042	2.89	1.35	13.14	10100	0.05	2.94	5.17	80	0.57
61	060-02-0029	2.80	4.55	11.05	18900	0.12	2.92	5.17	90	0.57
62	260-07-0016	2.50	4.94	10.76	17100	0.11	2.61	5.08	76	0.51
62	261-03-0015	2.58	5.12	5.62	12500	0.16	2.74	5.08	83	0.54
62	848-15-0005	2.36	2.11	2.46	5500	0.08	2.44	5.17	84	0.47



EAC Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
0.3	1	1	4.35	4.35
0.4	1	2	4.35	8.70
0.5	7	9	30.43	39.13
0.6	5	14	21.74	60.87
0.7	1	15	4.35	65.22
0.8	2	17	8.70	73.91
0.9	3	20	13.04	86.96
1.0	2	22	8.70	95.65
1.1	1	23	4.35	100.00

Figure 9.2: Frequency distribution of EAC for micro-surface projects

Comparative EAC's for alternate preventive maintenance treatments are provided in table 9.3, assuming treatment type would be permissible based on PCI distresses and traffic volumes for a particular project. This may be too simple a comparison, and other factors such as environment, availability of materials, and/or qualified contractors, etc., may have to be considered before deciding on the strategy.

Table 9.3: Cost-Effectiveness of Some Preventive Maintenance Treatments

Treatment Type	Average cost, $/sq yd	Average life, years	EAC, $/year
Chip seal	**1.35**	**4-6**	**0.33 - 0.23**
Micro-surface	**2.93**	**6-8**	**0.48 - 0.37**
Thin hot mix	**3.00**	**8-10**	**0.38 - 0.30**

Warranty in Preventive Maintenance Construction Contracts

One of the fringe benefits of the information collected in this study is the potential for drafting contracts with a warranty clause. A solid database is needed to decide the distress attributes, both in extent and severity, on which to base the warranty. For example, should the distress attributes be cracking and rutting for micro-surface and at what level? Furthermore, what level of cracking and/or raveling and/or bleeding should be allowed before warranty comes into play? Time may be the only factor to include for warranty application. This study is anticipated to provide enough information to initiate such a clause, or modify existing clauses based on valid data.

10. SUMMARY, FINDINGS AND RECOMMENDATIONS

Summary

The preceding sections discussed the field evaluation of 40 chip seals and 24 micro-surface projects to determine the life expectancy of these preventive maintenance treatments. The evaluation is based on data collected in the field over a five-year period (since construction) using subjective ratings of various distresses. ARAN measured data from the DOTD PMS files were also used in defining the pretreatment condition of the pavements. Using the pavement condition index (PCI) concept of pavement performance, the analysis and evaluation can be summed up in the following statements, which are confined to the system of materials, construction, and the environment in the study:

For chip seal treatment

- The median PCI of chip seal sections is about 75 after about 52 months of service.
- About 70 percent of the chip seals are in good to excellent condition.
- The effect of the pretreatment pavement condition on the performance of chip seals was not evident from the ARAN cracking data. However, the two sets of ARAN data, one before construction and the other after construction, show substantial improvement in the cracking distress due to the chip seal application.
- Almost 70 percent of the chip seal sections had some bleeding with about 20 percent of the sections showing moderate to high severity bleeding. In these sections, bleeding was evident during the first evaluation, indicating a construction and/or material problem.
- Rutting was minimal with only one section exceeding 0.5 inches of ruts.
- The subjective survey of various distresses provides information that relates to measured distress and can be used for routine rating of pavements.
- The friction numbers on most of the sections are in the 30s to 60s range.
- For a life expectancy of five years, the equivalent annual cost (EAC) is about $0.27.

For micro-surface treatment

- The median PCI of micro-surface sections is about 85 after 60 months of service.
- Only 10 percent of the 24 sections show PCI less than 80.
- The effect of pretreatment pavement condition on performance was not evident from the ARAN cracking data. However, the two sets of ARAN data, one before construction and the other after construction, show substantial improvement in the cracking distress due to the micro-surface application.
- Although rutting did not seem to be the primary reason for the application of this treatment since most of the ruts prior to treatment were less than half an inch, projects that had average ruts of 0.5 inches or more prior to treatment showed substantial reduction after the treatment.
- The friction numbers for smooth tire are in the low teens to low 30s on 50 percent of the projects. The same sections show FNs in the low 30s using ribbed tire. This can be traced to use of limestone aggregate on majority of these sections. Likewise, sandstone aggregate sections are in the 40s to 60s range after almost four years of service.
- For a life expectancy of six years, the equivalent annual cost (EAC) is about $0.49.

Recommendations

Based on the above statements and the observed condition of the treatment sections, it is recommended that:

- the DOTD continue field evaluation of all sections until the majority are taken out-of-service (end-of-life). This will also provide an excellent database for future determination of the effect of pretreatment condition of the pavement on the performance of the treatment;
- the subjective rating distress form of the type used in this study (figure 5.1) be utilized for survey of pavements on a routine basis, particularly prior to treatment application for the purpose mentioned above;

- the database developed in this study be used to add distress information on new projects programmed for preventive maintenance treatment, and that this distress information be used as guidelines for drafting warranty type specifications; and

- careful consideration be given to the use of limestone aggregate, which reduces the service life from a safety perspective when other mechanisms are performing satisfactorily.

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12. APPENDICES

APPENDIX A

Table A1: Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP*	PCI
03	235-01-0007	LA329	4.20	8/95	11/97	27	M/M(9.6)*	M/M(7.2)	M/M(4.8)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Fair(9.0)	32	68
				8/95	12/98	40	M/M(9.6)	M/M(7.2)	M/M(4.8)	None(0.1)	L/L(3.6)	0.35"(3.0)	L/L(0.1)	Fair(9.0)	39	61
				8/95	12/99	52	H/M(16.0)	M/M(7.2)	M/M(4.8)	None(0.1)	L/L(3.6)	0.35"(3.0)	L/L(1.5)	Fair(9.0)	45	55
				8/95	11/00	63	HH(20.0)	M/M(7.2)	M/M(4.8)	L/L(3.6)	L/L(3.6)	0.35"(3.0)	L/L(1.5)	Fair(9.0)	53	47
03	393-03-0013	LA343	5.23	8/95	11/97	27	H/M(16.0)	M/H(9.0)	L/L(0.8)	None(0.1)	L/L(3.6)	0.30"(3.0)	L/L(1.5)	Fair(9.0)	43	57
				8/95	12/98	40	H/M(16.0)	M/M(7.2)	L/L(0.8)	None(0.1)	M/M(6.4)	0.30"(3.0)	L/L(1.5)	F-P(12.0)	47	53
				8/95	12/99	52	H/M(16.0)	M/M(7.2)	L/L(0.8)	L/L(3.6)	M/M(6.4)	0.45"(3.0)	L/L(1.5)	F-P(12.0)	50	50
				8/95	10/00	63	H/M(16.0)	M/M(7.2)	L/L(0.8)	L/L(3.6)	M/M(6.4)	0.45"(3.0)	L/L(1.5)	F-P(12.0)	50	50
03	385-04-0004	LA92	2.70	11/96	11/97	12	None(0.2)	None(.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	5	95
				11/96	12/98	25	None(0.2)	None(.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	5	95
				11/96	12/99	37	None(0.2)	None(.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	10	90
				11/96	10/00	47	L/L(1.6)	None(.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	17	83
03	203-01-0007	LA29	4.14	8/95	11/97	27	H/H(20.0)	M/M(7.2)	M/M(4.8)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Fair (9.0)	42	58
				8/95	12/98	40	H/H(20.0)	H/H(15.0)	M/M(4.8)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	F-P(12.0)	53	47
				8/95	12/99	52	H/H(20.0)	H/H(15.0)	M/M(4.8)	None(0.1)	L/L(3.6)	<0.25(1.0)	None(0.1)	F-P(12.0)	57	43
				8/95	10/00	62	H/H(20.0)	H/H(15.0)	M/M(4.8)	None(0.1)	L/L(3.6)	<0.25(1.0)	None(0.1)	F-P(12.0)	57	43
03	850-08-0008	LA352	2.64	8/95	11/97	27	H/H(20.0)	H/H(15.0)	M/M(4.8)	L/L(3.6)	None(0.1)	0.35"(3.0)	None(0.1)	Fair (9.0)	56	44
				8/95	12/98	40	H/H(20.0)	H/H(15.0)	M/M(4.8)	L/L(3.6)	None(0.1)	0.60"(7.0)	None(0.1)	Fair(9.0)	60	40
				8/95	12/99	52	H/H(20.0)	H/H(15.0)	M/M(4.8)	L/L(3.6)	L/L(3.6)	0.60"(7.0)	None(0.1)	Fair(9.0)	63	37
				8/95	10/00	62	H/H(20.0)	H/H(15.0)	M/M(4.8)	L/L(3.6)	L/L(3.6)	0.60"(7.0)	None(0.1)	Fair(9.0)	63	37

* - deduct points (see Figure 5.1)

Table A1 (cont'd): Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
04	43-06-0020	LA9	7.49	8/96	6/97	10	H/H(20.0)	L/L(1.2)	L/L(0.8)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair (9.0)	37	63
				8/96	11/98	27	H/H(20.0)	L/L(1.2)	L/L(0.8)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	37	63
				8/96	11/98	39	H/H(20.0)	L/L(1.2)	L/L(0.8)	H/H(10.0)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	47	53
				8/96	10/00	50	H/H(20.0)	L/L(1.2)	L/L(0.8)	H/H(10.0)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	47	53
04	111-01-0016	LA531	7.92	8/96	6/97	10	None(0.2)	None(.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	5	95
				8/96	11/98	27	None(0.2)	None(.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	5	95
				8/96	11/99	39	L/L(1.6)	None(.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Good(3.0)	8	92
				8/96	10/00	50	L/L(1.6)	None(.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Good(3.0)	8	92
04	85-03-0013	LA160	6.26	8/95	6/97	22	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Fair (9.0)	24	76
				8/95	11/98	39	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Fair(9.0)	24	76
				8/95	11/99	51	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	26	74
				8/95	10/00	62	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	26	74
04	82-05-0006	LA157	7.22	10/96	6/97	8	L/L(1.6)	L/L(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	None(0.1)	Good(3.0)	11	89
				10/96	11/98	25	L/L(1.6)	L/L(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	None(0.1)	Good(3.0)	11	89
				10/96	11/99	37	L/L(1.6)	L/L(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	12	88
				10/96	10/00	48	L/L(1.6)	L/L(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	18	82
05	166-05-0005	LA132	4.99	9/95	6/97	21	M/M(9.6)	None(0.15	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Fair(9.0)	20	80
				9/95	11/98	38	M/H(12.0)	M/H(9.0)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Fair(9.0)	31	69
				9/95	11/99	50	M/H(12.0)	M/M(7.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	31	69
				9/95	10/00	61	H/H(20.0)	M/M(7.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	M/L(3.0)	Fair(9.0)	39	61
05	37-02-0032	LA2	9.00	10/95	6/97	20	M/L(4.8)	None(0.15	L/L(0.8)	L/L(3.6)	M/M(6.4)	<0.25(1.0)	L/M(2.4)	Fair(9.0)	28	72
				10/95	11/98	37	M/M(9.6)	None(0.15	L/L(0.8)	L/L(3.6)	M/H(8.0)	<0.25(1.0)	M/H(6.0)	Fair(9.0)	38	62
				10/95	11/99	49	M/M(9.6)	None(0.15	L/L(0.8)	M/H(3.6)	M/H(8.0)	0.35" (3.0)	M/H(6.0)	Fair(9.0)	40	60
				10/95	10/00	60	M/M(9.6)	None(0.15	L/L(0.8)	M/H(3.6)	M/H(8.0)	0.35" (3.0)	M/H(6.0)	Fair(9.0)	40	60

Table A1 (cont'd): Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
07	199-01-0006	LA102	7.43	11/96	11/97	12	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	8	92
				11/96	12/98	25	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	8	92
				11/96	12/99	37	L/M(12.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	22	78
				11/96	10/00	47	L/M(12.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	22	78
07	31-08-0017	LA27	11.72	11/96	11/97	12	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.5(1.0)	L/M(2.4)	Good(3.0)	12	88
				11/96	12/98	25	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/M(2.4)	Good(3.0)	15	85
				11/96	12/99	37	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	<0.25(1.0)	L/M(2.4)	Good(3.0)	18	82
				11/96	10/00	47	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	<0.25(1.0)	L/M(2.4)	Fair(9.0)	24	76
07	382-04-0033	LA384	5.66	8/95	11/97	27	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	14	86
				8/95	12/98	40	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	14	86
				8/95	12/99	52	M/1(4.8)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.30" (3.0)	M/L(3.0)	Good(3.0)	21	79
				8/95	10/00	62	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab		Rehab
07	193-02-0041	LA27	5.45	6/96	11/97	17	None(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	0.30" (3.0)	L/L(1.5)	Good(3.0)	8	92
				6/96	12/98	30	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	0.35" (3.0)	None(0.1)	Good(3.0)	8	92
				6/96	12/99	42	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.35" (3.0)	L/L(1.5)	Good(3.0)	13	87
				6/96	10/00	52	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.35" (3.0)	L/L(1.5)	Good(3.0)	15	85
07	193-03-0008	LA27	2.13	6/96	11/97	17	None(0.2)	None(0.15	None(0.1)	None(0.1)	L/L(3.6)	0.30 (3.0)	L/L(1.5)	Good(3.0)	12	88
				6/96	12/98	30	None(0.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.35 (3.0)	L/L(1.5)	Good(3.0)	12	88
				6/96	12/99	42	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.35" (3.0)	L/L(1.5)	Good(3.0)	16	84
				6/96	10/00	52	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.35" (3.0)	L/L(1.5)	Good(3.0)	16	84
07	193-04-0008	LA27	6.24	6/96	11/97	17	None(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	5	95
				6/96	12/98	30	None(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Good(3.0)	6	94
				6/96	12/99	42	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.35" (3.0)	L/L(1.5)	Good(3.0)	16	84
				6/96	10/00	52	M/L(4.8)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.35" (3.0)	M/M(4.8)	Good(3.0)	20	80
07	196-01-0019	LA14	7.27	11/96	11/97	12	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.5(1.0)	L/L(1.5)	Good(3.0)	11	89
				11/96	12/98	25	L/L(1.6)	None(0.1)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Good(3.0)	11	89
				11/96	12/98	37	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.30" (3.0)	L/L(1.5)	Good(3.0)	13	87
				11/96	10/00	47	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.30" (3.0)	L/L(1.5)	Good(3.0)	15	85

Table A1 (cont'd): Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
07	193-05-0015	LA14	4.97	6/96	11/97	17	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.35(3.0)	L/L(1.5)	Good(3.0)	21	79
				6/96	12/98	30	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.35(3.0)	L/L(1.5)	Good(3.0)	21	79
				6/96	12/99	42	H/M(16.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.40(3.0)	M/M(4.8)	Good(3.0)	31	69
				6/96	10/00	52	H/M(16.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.40(3.0)	M/M(4.8)	Good(3.0)	31	69
07	827-31-0003	LA3056	1.89	9/95	11/97	26	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	6	94
				9/95	12/98	39	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	6	94
				9/95	12/99	51	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	6	94
				9/95	10/00	61	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Fair(9.0)	14	86
07	812-08-0003	LA3056	2.33	9/95	11/97	26	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	8	92
				9/95	12/98	39	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	6	94
				9/95	12/99	51	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	8	92
				9/95	10/00	61	L/M(3.2)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Fair(9.0)	16	84

Table A1(cont'd): Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
08	57-08-0012	US167	3.57	10/95	6/97	20	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Fair(9.0)	14	86
				10/95	11/98	37	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Fair(9.0)	20	80
				10/95	11/98	49	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Fair(9.0)	21	79
				10/95	10/00	60	M/H(12.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	None(0.1)	Fair(9.0)	26	74
08	858-12-0001	LA489	2.80	3/97	11/98	20	L/L(1.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	8	92
				3/97	11/99	32	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	1 6	84
				3/97	10/00	43	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	1 6	84
08	365-01-0008	LA472	8.77	3/97	11/98	20	None(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	5	95
				3/97	11/99	32	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	6	94
				3/97	10/00	41	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Fair(9.0)	12	88
58	143-05-0021	LA124	5.48	4/97	11/98	19	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Good(3.0)	19	81
				4/97	11/99	31	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Good(3.0)	19	81
				4/97	10/00	42	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Fair(9.0)	25	75
58	143-06-0023	LA124	4.36	4/97	11/98	19	M/M(9.6)	M/M(7.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Good(3.0)	26	74
				4/97	11/99	31	M/M(9.6)	L/L(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Fair(9.0)	20	80
				4/97	10/00	42	H/H(20.0)	L/L(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Fair(9.0)	36	64
58	152-02-0008	LA8	2.29	8/95	11/98	39	H/H(20.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	25	75
				8/95	11/99	51	H/H(20.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	25	75
				8/95	10/00	62	H/H(20.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	G-F(6.0)	28	72
58	39-04-0043	LA8	3.83	10/96	6/97	8	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	6	94
				10/96	11/98	25	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	None(0.1)	Good(3.0)	14	86
				10/96	11/99	37	H/M(16.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Good(3.0)	26	74
				10/96	10/00	48	M/H(16.0)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	L/L(1.5)	Good(3.0)	26	74
58	173-01-0025	LA4	4.65	4/97	11/98	19	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.)	L/L(1.5)	Good(3.0)	9	91
				4/97	11/99	31	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	None(0.1)	Good(3.0)	11	89
				4/97	10/00	42	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	None(0.1)	Good(3.0)	11	89

Table A1(cont'd): Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRA CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
58	36-04-0049	LA4	7.15	10/96	6/97	8	None(0.2	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	None(0.1)	Good(3.0)	5	95
				10/96	11/98	25	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Good(3.0)	6	94
				10/96	11/99	37	L/L(1.6)	None(0.1)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Good(3.0)	8	92
				10/96	10/00	48	M/L(4.8)	None(0.1)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	M/M(4.8)	Fair(9.0)	24	76
58	51-03-0027	LA17	12.91	8/95	6/97	22	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.30" (3.0)	None(0.1)	Good(3.0)	10	90
				8/95	11/98	39	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	0.30" (3.0)	None(0.1)	Good(3.0)	12	88
				8/95	11/99	51	L/L(1.6)	None(0.15)	L/L(0.8)	None(0.1)	L/L(3.6)	0.65" (7.0)	None(0.1)	Good(3.0)	18	82
				8/95	10/00	62	L/L(1.6)	None(0.15)	L/L(0.8)	None(0.1)	L/L(3.6)	0.65" (7.0)	None(0.1)	Good(3.0)	18	82
61	863-02-0022	LA421	6.92	5/96	·12/97	19	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	14	84
				5/96	12/98	31	L/L(1.6)	None(0.15)	None(0.1)	L/L(3.6)	L/L(3.6)	<0.25(3.0)	L/L(1.5)	Fair(9.0)	17	83
				5/96	11/99	42	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	17	83
				5/96	10/00	53	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	17	83
61	804-28-0008	LA1015	0.66	7/96	12/97	17	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(3.0)	L/L(1.5)	Fair(9.0)	14.	86
				7/96	12/98	29	L/M(3.2)	L/L(1.2)	None(0.1)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	20	80
				7/96	12/99	41	L/M(3.2)	M/M(7.2)	None(0.1)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	27	73
				7/96	02/01	55	L/M(3.2)	M/M(9.0)	None(0.1)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	27	73
61	804-29-0009	LA1015	0.76	7/96	12/97	17	L/L(1.6)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	L/L(1.5)	Fair(9.0)	15	85
				7/96	12/98	29	L/L(1.6)	M/M(7.2)	L/L(0.8)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	F-P(12.0)	28	72
				7/96	12/99	41	L/L(1.6)	M/M(7.2)	L/L(0.8)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	F-P(12.0)	28	72
				7/96	02/01	55	L/L(1.6)	H/H(15.0)	L/L(0.8)	L/L(3.6)	None(0.1)	<0.25(1.0)	L/L(1.5)	F-P(12.0)	34	66
61	804-38-0006	LA1016	3.65	7/96	12/97	17	M/M(9.6)	H/H(15.0)	H/H(10.0)	None(0.1)	None(0.1)	0.35" (3.0)	L/L(1.5)	Fair(9.0)	48.	52.
				7/96	12/98	29	M/M(9.6)	H/H(15.0)	H/H(10.0)	L/L(3.6)	None(0.1)	0.40 ("3.0)	L/L(1.5)	Poor(15.0	58	42
				7/96	12/99	41	Rehab	Rehab							**	**
61	804-20-0003	LA999	1.29	7/96	12/97	17	L/L(1.6)	M/M(7.2)	L/L(1.6)	None(0.1)	None(0.1)	0.30" (3.0)	L/L(1.5)	Fair(9.0)	24.	76
				7/96	12/98	29	M/M(9.6)	M/H(9.0)	L/L(0.8)	L/L(3.6)	L/L(3.6)	0.30" (3.0)	L/L(1.5)	Poor(15.)	46	54
				7/96	12/99	41	M/M(9.6)	N/H(9.0)	L/L(0.8)	L/L(3.6)	L/L(3.6)	0.30" (3.0)	L/L(1.5)	Poor(15.)	44	56
				7/96	02/01	55	M/H(12.)	M/H(9.0)	L/L(0.8)	L/L(3.6)	L/L(3.6)	0.30" (3.0)	L/L(1.5)	Poor(15.)	48	52

Table A1(cont'd): Summary of Condition Survey of Chip Seal Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, IN	AGG LOSS	ROUGHNESS	TDP	PCI
62	859-09-0017	LA430	8.83	4/97	12/97	8	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	M/M((6.4)	<0.25(3.)	M/H(6.0)	Fair(9.0)	26	74
				4/97	12/98	20	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	<0.25(3.)	M/M(6.0)	Fair(9.0)	26	74
				4/97	12/99	32	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	H/H(10.0)	<0.25(1.)	M/H(6.0)	Fair(9.0)	30	70
				4/97	10/00	42	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	H/H(10.0)	<0.25(1.)	M/H(6.0)	Fair(9.0)	30	70
62	278-05-0005	LA1061	4.56	4/97	12/97	8	None(0.2)	None(0.15)	L/L(0.8)	L/L(3.6)	L/L(3.6)	0.35" (3.)	M/M(4.8)	Fair(9.0)	25	75
				4/97	12/98	20	L/M(3.2)	L/L(1.2)	L/L(0.8)	L/L(3.6)	M/M(6.4)	0.35" (3.)	M/M(4.8)	Fair(9.0)	32	68
				4/97	12/99	32	L/L(1.6)	L/L(1.2)	L/L(0.8)	L/L(3.6)	M/M(6.4)	0.35" (3.)	M/M(4.8)	Fair(9.0)	28	72
				4/97	10/00	42	L/L(1.6)	L/L(1.2)	L/L(0.8)	L/L(3.6)	M/M(6.4)	0.35" (3.)	M/M(4.8)	Fair(9.0)	28	72
62	260-09-0005	LA441	3.80	11/95	12/97	25	M/H(12.0)	None(0.15)	None(0.1)	None(0.1)	M/L(4.8)	0.35" (3.)	M/M(4.8)	Poor(15.)	40	60
				11/95	12/98	37	H/H(20.0)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.40" (3.)	M/M(4.8)	F-P(12.0)	47	53
				11/95	12/99	49	H/H(20.0)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.40" (3.)	M/M(4.8)	F-P(12.0)	45	55
				11/95	10/00	59	H/H(20.0)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.40" (3.)	M/M(4.8)	F-P(12.0)	45	55
62	260-06-0009	LA43	3.69	11/95	12/97	25	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.)	M/M(4.8)	Fair(9.0)	20	80
				11/95	12/98	37	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(4.8)	<0.25(1.)	M/M(4.8)	Fair(9.0)	22	78
				11/95	12/99	49	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(4.8)	<0.25(1.)	M/M(4.8)	Fair(9.0)	22	78
				11/95	10/00	59	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(4.8)	0.30(3.)	M/M(4.8)	Fair(9.0)	24	76

Table A2 - Preconstruction Condition Rating of Chip Seal Sections

DIST	PROJ_NO	RUT1	RUT RATE	IRI1	IRI RATE	RANDOM CRACK	RANDOM CRACK RATE	ALLIG CRACK	ALLIG CRACK RATE	AGE6	PCI6	DIFF IN PCI	RATE OF CHANGE	CRKRATE
3	235-01-0007	0.30	2	188	3	114	1	445	1	63	47	53	0.84127	1
3	393-03-0013	0.29	2	129	2	404	1	770	2	63	50	50	0.79365	2
3	385-04-0004	0.27	2	257	3	3	1	193	1	47	90	10	0.21277	1
3	203-01-0007	0.29	2	175	2	261	1	413	1	62	43	57	0.91935	1
3	850-08-0008	0.43	2	199	3	0	1	1534	3	62	37	63	1.01613	3
4	043-06-0020	0.20	1	141	2	318	1	198	1	50	53	47	0.94000	1
4	111-01-0016	0.20	1	83	1	814	2	18	1	50	92	8	0.16000	2
4	085-03-0013	0.18	1	170	2	2245	3	6	1	62	74	26	0.41935	3
4	082-05-0006	0.25	1	117	2	457	1	5	1	48	82	18	0.37500	1
5	166-05-0005	0.18	1	173	2	0	1	0	1	61	69	31	0.50820	1
5	037-02-0032	0.30	2	191	3	667	2	568	1	60	60	40	0.66667	2
7	199-01-0006	0.15	1	104	2	1174	2	324	1	47	78	22	0.46809	2
7	031-08-0017	0.28	2	114	2	2177	3	1419	2	47	76	24	0.51064	3
7	382-04-0033	0.37	2	145	2	4	1	0	1	.	.	.	.	1
7	193-02-0041	0.48	2	108	2	8	1	241	1	52	85	15	0.28846	1
7	193-03-0008	0.58	3	93	1	1470	2	528	1	52	84	16	0.30769	2
7	193-04-0008	0.51	3	104	2	2339	3	632	1	52	84	16	0.30769	3
7	196-01-0019	0.27	2	110	2	200	1	358	1	47	85	15	0.31915	1
7	193-05-0015	0.50	2	86	1	123	1	229	1	52	69	31	0.59615	1
7	827-31-0003	0.20	1	173	2	2144	3	202	1	61	86	14	0.22951	3
7	812-08-0003	0.26	2	203	3	1560	3	336	1	61	84	16	0.26230	3
8	057-08-0012	0.20	1	111	2	327	1	10	1	60	74	26	0.43333	1
8	858-12-0001	0.12	1	167	2	72	1	0	1	43	84	16	0.37209	1
8	365-01-0008	0.20	1	146	2	624	2	299	1	41	88	12	0.29268	2
58	143-05-0021	.	1	.	1	.	1	.	1	42	75	25	0.59524	1
58	143-06-0023	0.30	2	115	2	404	1	84	1	42	64	36	0.85714	1
58	152-02-0008	0.20	1	149	2	1366	2	4339	3	62	72	28	0.45161	3
58	039-04-0043	.	1	.	1	.	1	.	1	48	74	26	0.54167	1
58	173-01-0025	0.18	1	144	2	1384	2	82	1	42	89	11	0.26190	2
58	036-04-0049	0.26	2	120	2	242	1	369	1	48	76	24	0.50000	1
58	051-03-0027	0.25	1	105	2	478	1	2	1	62	82	18	0.29032	1
61	863-02-0022	.	1	.	1	.	1	.	1	53	83	17	0.32075	1
61	804-28-0008	0.30	2	226	3	4	1	982	2	55	73	27	0.49091	2
61	804-29-0009	0.40	2	317	3	84	1	53	1	55	66	34	0.61818	1
61	804-38-0006	0.30	2	262	3	10	1	0	1	.	.	.	.	1
61	804-20-0003	0.20	1	283	3	110	1	238	1	55	52	48	0.87273	1
62	859-09-0017	.	1	.	1	.	1	.	1	42	70	30	0.71429	1
62	278-05-0005	.	1	.	1	.	1	.	1	42	72	28	0.66667	1
62	260-09-0005	0.18	1	123	2	1307	2	0	1	59	55	45	0.76271	2
62	260-06-0009	0.36	2	138	2	1002	2	0	1	59	76	24	0.40678	2

Table A3 - Aggregate Type and Source used on Chip Seal projects

OBS	Project Number	Material Code	Material Description	Purp Code	Spec Code	Pass Fail	Date Sampled	Source Code	Description of Source Code	
1	031-08-0017	454	EXPANDED SHALE	3	1	0	09/23/96	AB10	TXI (STREETMAN)	STREETMAN, TX
2	031-08-0017	454	EXPANDED SHALE	3	1	0	09/23/96	AB10	TXI (STREETMAN)	STREETMAN, TX
3	031-08-0017	454	EXPANDED SHALE	3	1	0	09/23/96	AB10	TXI (STREETMAN)	STREETMAN, TX
4	036-04-0049	454	EXPANDED SHALE	3	1	1	08/07/96	AB10	TXI (STREETMAN)	STREETMAN, TX
5	036-04-0049	454	EXPANDED SHALE	3	1	0	08/12/96	AB10	TXI (STREETMAN)	STREETMAN, TX
6	036-04-0049	454	EXPANDED SHALE	3	1	1	08/12/96	AB10	TXI (STREETMAN)	STREETMAN, TX
7	036-04-0049	454	EXPANDED SHALE	3	1	0	08/13/96	AB10	TXI (STREETMAN)	STREETMAN, TX
8	036-04-0049	454	EXPANDED CLAY-BLACK	3	1	1	08/08/96	AB12	TXI (CLODINE)(BLK.)	HOUSTON, TX
9	036-04-0049	454	EXPANDED CLAY-BLACK	3	1	1	08/09/96	AB12	TXI (CLODINE)(BLK.)	HOUSTON, TX
10	036-04-0049	458	EXPANDED SHALE	3	1	0	08/05/96	AB10	TXI (STREETMAN)	STREETMAN, TX
11	036-04-0049	458	EXPANDED CLAY-BLACK	3	1	0	08/08/96	AB12	TXI (CLODINE)(BLK.)	HOUSTON, TX
12	037-02-0032	453		3	1	1	08/25/95	9999		
13	037-02-0032	453		3	1	1	09/19/95	9999		
14	037-02-0032	453		3	1	1	09/19/95	9999		
15	037-02-0032	453		3	1	0	09/19/95	9999		
16	037-02-0032	453		3	1	0	09/19/95	9999		
17	043-06-0020	454	EXPANDED SHALE	3	5	1	05/10/96	AB10	TXI (STREETMAN)	STREETMAN, TX
18	043-06-0020	454	EXPANDED SHALE	3	4	0	05/10/96	AB10	TXI (STREETMAN)	STREETMAN, TX
19	043-06-0020	454	EXPANDED SHALE	3	5	1	05/13/96	AB10	TXI (STREETMAN)	STREETMAN, TX
20	043-06-0020	454	EXPANDED SHALE	3	4	0	05/13/96	AB10	TXI (STREETMAN)	STREETMAN, TX
21	043-06-0020	454	EXPANDED SHALE	4	4	0	05/20/96	AB10	TXI (STREETMAN)	STREETMAN, TX
22	043-06-0020	454	EXPANDED SHALE	4	5	1	05/20/96	AB10	TXI (STREETMAN)	STREETMAN, TX
23	043-06-0020	454	EXPANDED SHALE	4	5	1	05/22/96	AB10	TXI (STREETMAN)	STREETMAN, TX
24	051-03-0027	458	EXPANDED SHALE	3	1	0	07/17/95	AB10	TXI (STREETMAN)	STREETMAN, TX
25	051-03-0027	458	EXPANDED SHALE	3	1	0	07/18/95	AB10	TXI (STREETMAN)	STREETMAN, TX
26	051-03-0027	458	EXPANDED SHALE	3	1	0	07/20/95	AB10	TXI (STREETMAN)	STREETMAN, TX
27	057-08-0012	454	ERRONEOUSLY ISSUED)	3	1	1	08/07/95	A614	(INACTIVE-4/96) BIG RIVER INDS.(NOW AB25-CODE A614	
28	057-08-0012	454	ERRONEOUSLY ISSUED)	3	1	0	08/09/95	A614	(INACTIVE-4/96) BIG RIVER INDS.(NOW AB25-CODE A614	
29	085-03-0013	352	R. STONE(NOVACULITE)	3	1	0	08/02/95	AA44	MID-STATE CONST.& MAT'L.(MALVERN)	LITTLE ROCK,A
30	085-03-0013	358	R. STONE(NOVACULITE)	3	1	0	08/02/95	AA44	MID-STATE CONST.& MAT'L.(MALVERN)	LITTLE ROCK,A
31	085-03-0013	436	FINE SAND (HMAC)	3	1	1	08/02/95	AJ72	(INACTIVE-11/00) L.J. EARNEST	SHREVEPORT
32	085-03-0013	436	FINE SAND (HMAC)	3	1	1	08/23/95	AJ72	(INACTIVE-11/00) L.J. EARNEST	SHREVEPORT
33	085-03-0013	436	FINE SAND (HMAC)	3	1	0	09/05/95	AJ72	(INACTIVE-11/00) L.J. EARNEST	SHREVEPORT
34	085-03-0013	458	EXPANDED SHALE	3	1	0	08/03/95	AB10	TXI (STREETMAN)	STREETMAN, TX
35	085-03-0013	458	EXPANDED SHALE	3	1	0	08/03/95	AB10	TXI (STREETMAN)	STREETMAN, TX
36	166-05-0005	454	EXPANDED SHALE	3	1	0	08/16/96	AB10	TXI (STREETMAN)	STREETMAN, TX
37	193-02-0041	454	EXPANDED SHALE	3	1	1	05/17/96	AB10	TXI (STREETMAN)	STREETMAN, TX
38	193-02-0041	454	EXPANDED SHALE	3	1	1	05/17/96	AB10	TXI (STREETMAN)	STREETMAN, TX
39	193-02-0041	454	EXPANDED SHALE	3	1	1	05/17/96	AB10	TXI (STREETMAN)	STREETMAN, TX
40	203-01-0007	458	ERRONEOUSLY ISSUED)	3	1	0	07/24/95	A614	(INACTIVE-4/96) BIG RIVER INDS.(NOW AB25-CODE A614	
41	203-01-0007	458	ERRONEOUSLY ISSUED)	3	1	0	07/24/95	A614	(INACTIVE-4/96) BIG RIVER INDS.(NOW AB25-CODE A614	
42	203-01-0007	458	ERRONEOUSLY ISSUED)	3	1	0	07/25/95	A614	(INACTIVE-4/96) BIG RIVER INDS.(NOW AB25-CODE A614	
43	203-01-0007	458	ERRONEOUSLY ISSUED)	3	1	0	07/25/95	A614	(INACTIVE-4/96) BIG RIVER INDS.(NOW AB25-CODE A614	
44	260-06-0009	453	STONE (SANDSTONE)	3	1	0	10/06/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
45	260-06-0009	457	STONE (SANDSTONE)	3	1	1	10/06/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
46	260-06-0009	457	STONE (SANDSTONE)	3	1	1	10/09/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
47	260-06-0009	457	STONE (SANDSTONE)	3	1	1	10/16/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
48	278-05-0005	457	STONE (SANDSTONE)	1	1	0	09/26/96	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
49	278-05-0005	457	STONE (SANDSTONE)	1	1	0	09/26/96	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
50	278-05-0005	457	STONE (SANDSTONE)	1	1	1	10/16/96	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
51	278-05-0005	457	STONE (SANDSTONE)	1	1	1	10/16/96	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK)	NEW ORLEANS,LA
52	278-05-0005	458	EXPANDED SHALE	3	2	0	04/10/97	AB10	TXI (STREETMAN)	STREETMAN, TX
53	278-05-0005	458	EXPANDED SHALE	3	2	0	04/21/97	AB10	TXI (STREETMAN)	STREETMAN, TX
54	278-05-0005	458	EXPANDED CLAY-BLACK	4	2	1	04/25/97	AB12	TXI (CLODINE)(BLK.)	HOUSTON, TX

Table A3(cont'd) - Aggregate Type and Source used on Chip Seal Projects

OBS	Project Number	Material Code	Material Description	Purp Code	Spec Code	Pass Fail	Date Sampled	Source Code	Description of Source Code
55	278-05-0005	458	EXPANDED CLAY-BLACK	4	2	1	04/25/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
56	278-05-0005	458	EXPANDED CLAY-BLACK	3	2	1	03/31/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
57	278-05-0005	458	EXPANDED CLAY-BLACK	4	2	1	04/04/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
58	278-05-0005	458	EXPANDED CLAY-BLACK	4	2	1	04/16/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
59	278-05-0005	458	EXPANDED CLAY-BLACK	3	2	0	04/18/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
60	278-05-0005	458	EXPANDED CLAY-BLACK	4	2	0	04/25/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
61	278-05-0005	458	EXPANDED CLAY-BLACK	4	2	0	04/25/97	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
62	382-04-0033	453	STONE (SANDSTONE)	1	1	1	11/07/94	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
63	382-04-0033	453	STONE (SANDSTONE)	1	1	0	11/07/94	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
64	382-04-0033	453	STONE (SANDSTONE)	1	1	0	11/07/94	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
65	382-04-0033	453	STONE (SANDSTONE)	3	1	0	11/14/94	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
66	382-04-0033	453	STONE (SANDSTONE)	3	1	0	11/14/94	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
67	382-04-0033	453	EXPANDED SHALE	3	1	0	10/10/94	AB10	TXI (STREETMAN) STREETMAN, TX
68	382-04-0033	453	EXPANDED SHALE	3	1	1	10/10/94	AB10	TXI (STREETMAN) STREETMAN, TX
69	382-04-0033	453	EXPANDED SHALE	4	1	1	10/12/94	AB10	TXI (STREETMAN) STREETMAN, TX
70	382-04-0033	453	EXPANDED SHALE	4	1	1	10/12/94	AB10	TXI (STREETMAN) STREETMAN, TX
71	382-04-0033	453	EXPANDED SHALE	3	1	1	10/14/94	AB10	TXI (STREETMAN) STREETMAN, TX
72	382-04-0033	453	EXPANDED SHALE	3	1	0	10/14/94	AB10	TXI (STREETMAN) STREETMAN, TX
73	382-04-0033	453	STONE (SANDSTONE)	3	1	1	09/01/94	AO61	ARKHOLA SAND & GRAVEL FT. SMITH, AR.
74	382-04-0033	453	STONE (SANDSTONE)	3	1	1	09/01/94	AO61	ARKHOLA SAND & GRAVEL FT. SMITH, AR.
75	382-04-0033	454	EXPANDED SHALE	3	1	0	11/14/94	AB10	TXI (STREETMAN) STREETMAN, TX
76	382-04-0033	454	EXPANDED SHALE	3	1	0	11/14/94	AB10	TXI (STREETMAN) STREETMAN, TX
77	385-04-0004	454	EXPANDED CLAY-BLACK	3	1	1	09/26/96	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
78	385-04-0004	454	EXPANDED CLAY-BLACK	4	4	0	10/03/96	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
79	385-04-0004	454	EXPANDED CLAY-BLACK	4	4	0	10/03/96	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
80	385-04-0004	458	EXPANDED CLAY-BLACK	3	1	1	09/26/96	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
81	385-04-0004	458	EXPANDED CLAY-BLACK	4	4	0	10/03/96	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
82	385-04-0004	458	EXPANDED CLAY-BLACK	4	4	0	10/03/96	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
83	812-08-0003	454	EXPANDED CLAY-BLACK	3	1	1	08/02/95	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
84	812-08-0003	454	EXPANDED CLAY-BLACK	3	1	1	08/08/95	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
85	812-08-0003	454	EXPANDED CLAY-BLACK	3	1	1	08/08/95	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
86	812-08-0003	454	EXPANDED CLAY-BLACK	3	1	1	08/16/95	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
87	812-08-0003	454	EXPANDED CLAY-BLACK	3	1	0	08/23/95	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
88	812-08-0003	454	EXPANDED CLAY-BLACK	3	1	0	08/23/95	AB12	TXI (CLODINE)(BLK.) HOUSTON, TX
89	863-02-0022	458	EXPANDED CLAY LT.WT.	3	1	0	09/22/95	AB25	BIG RIVER INDUSTRIES, INC. ERWINVILLE
90	863-02-0022	458	EXPANDED CLAY LT.WT.	3	1	0	09/22/95	AB25	BIG RIVER INDUSTRIES, INC. ERWINVILLE
91	863-02-0022	458	EXPANDED CLAY LT.WT.	3	1	0	05/28/96	AB25	BIG RIVER INDUSTRIES, INC. ERWINVILLE

APPENDIX B

Table B1 -Summary of Condition Survey of Micro-Surface Projects

Table B2 - Preconstruction Condition Rating of Micro-Surface Sections

Table B3 - Aggregate Type and Source used on Micro-Surface Projects

Table B1: Summary of Condition Survey of Micro-surface Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP*	PCI
02	018-01-0026	US11	5.86	5/95	12/97	31	L/M(3.2)*	L/L(1.2)	M/M(4.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.0)	Good(3.0)	14	86
				5/95	12/98	43	L/M(3.2)	L/L(1.2)	M/M(4.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	14	86
				5/95	12/99	55	M/M(9.6)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	16	84
				5/95	02/01	69	M/M(9.6)	None(0.1)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	F-G(6.0)	18	82
02	148-01-0023	LA47	1.45	12/95	12/97	24	L/L(1.6)	None(0.15)	None(0.1)	None((0.1)	L/L(3.6)	<0.25(1.0)	L/L(3.6	Good(3.0)	10	90
				12/95	12/98	36	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(3.6	Good(3.0)	10	90
				12/95	12/99	48	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	L/L(3.6	Good(3.0)	11	89
				12/95	02/01	62	Rehab							Rehab	Reha	
02	410-02-0014	LA428	1.85	10/95	12/97	26	M/L(4.8)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				10/95	12/98	38	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	14	86
				10/95	12/99	50	M/H(12.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	17	83
				10/95	02/01	64	M/H(12.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	17	83
02	410-01-0026	LA428	1.11	10/95	12/97	26	M/L(4.8)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				10/95	12/98	38	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	14	86
				10/95	12/99	50	M/H(12.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	17	83
				10/95	02/01	64	M/H(12.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	17	83
02	826-38-0007	LA3018	1.62	2/97	12/97	10	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	6	94
				2/97	12/98	22	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				2/97	12/99	34	L/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	G00d(3.0)	14	86
				2/97	02/01	48	L/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	G00d(3.0)	14	86
02	424-08-0023	US90	3.6	2/97	12/97	10	L/M((3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				2/97	12/98	22	L/M(3.2)	L/L(1.2)	L/L(0.8)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	13	87
				2/97	12/99	34	L/M(3.2)	L/L(1.2)	L/L(0.8)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	13	87
				2/97	02/01	48	L/M(3.2)	L/L(1.2)	L/L(0.8)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	13	87
02	855-04-0051	LA659	2.71	1/96	12/97	24	L/L(1.6)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	6.9	93
				1/96	12/98	36	L/M(3.2)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	9.5	90
				1/96	12/99	48	L/M(3.2)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	0.25(3.0)	N(0.1)	Good(3.0)	12	88
				1/96	02/01	61	L/M(3.2)	L/L(1.2)	L/L(0.8)	L/L(3.6)	None(0.1)	0.25(3.0)	N(0.1)	Good(3.0)	15	85

Table B1 (cont'd): Summary of Condition Survey of Micro-surface Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
03	828-12-0011	LA339	2.57	6/97	11/97	5	None(0.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				6/97	12/98	18	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				6/97	12/99	30	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.35"(3.0)	N(0.1)	Good(3.0)	14	86
				6/97	11/00	41	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	M/M(6.4)	0.35"(3.0)	N(0.1)	Good(3.0)	14	86
03	380-04-0012	LA103	2.20	6/96	11/97	17	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	14	86
				6/96	12/98	30	M/H(12.0)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	18	82
				6/96	12/98	42	M/M(12.0)	None(1.2)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	21	79
				6/96	11/00	53	M/M(12.0)	None(1.2)	None(0.1)	L/L(3.0)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	25	75
04	010-05-0029	US71	5.16	7/95	6/97	23	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	20	80
				7/95	11/98	40	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	20	80
				7/95	11/99	52	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	20	80
				7/95	10/00	63	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	20	80
05	51-04-0015	LA17	2.39	12/96	6/97	6	None(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	5	95
				12/96	11/98	23	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	6	94
				12/96	11/99	35	L/L(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				12/96	10/00	46	L/L(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
05	71-01-0022	LA137	7.12	6/95	6/97	24	None(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	5	95
	26-08-0024	LA15	0.21	6/95	11/98	41	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	6	94
				6/95	11/99	53	L/L(1.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	6	94
				6/95	10/00	64	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
05	451-07-0049	I20	6.48	8/96	11/98	27	None(0.2)	None(0.15)	None(0.1)	L/L(3.6)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				8/96	11/99	39	None(0.2)	None(0.15)	None(0.1)	L/L(3.6)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				8/96	10/00	50	None(0.2)	None(0.15)	None(0.1)	L/L(3.6)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
05	69-02-0018	LA33	5.72	1/97	11/98	22	L/H(4.0)	L/H(3.0)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	11	89
				1/97	11/99	34	L/H(4.0)	L/H(3.0)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	11	89
				1/97	10/00	45	L/H(4.0)	L/H(3.0)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	11	89

Table B1 (cont'd): Summary of Condition Survey of Micro-surface Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
07	200-01-0006	LA104	4.70	1/97	11/97	10	L/H(4.0)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	9	91
				1/97	12/98	23	L/H(4.0)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				1/97	12/99	35	L/H(4.0)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				1/97	11/00	46	L/H(4.0)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
07	193-31-0022	LA397	5.12	9/95	11/97	26	L/L(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	5	95
				9/95	12/98	39	L/L(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	5	95
				9/95	12/99	51	L/L(0.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N90.1)	Good(3.0)	5	95
				9/95	11/00	62	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
08	15-03-0021	US165	6.21	9/95	6/97	21	M/M(9.6)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	15	85
				9/95	11/98	38	M/M(9.6)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	15	85
				9/95	11/99	50	M/M(9.6)	L/L(1.2)	L/L(0.8)	NOne(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	16	84
				9/95	10/00	61	M/M(9.6)	L/L(1.2)	L/L(0.8)	NOne(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	16	84
08	25-02-0031	US171	5.26	8/95	11/98	39	L/M(3.2)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	9	91
				8/95	11/99	51	L/M(3.2)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	9	91
				8/95	10/00	62	M/H(12.0)	L/L(1.2)	None(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	18	82
58	26-03-0029	US65	2.59	7/95	6/97	23	L/L(1.6)	L/L(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	7	93
				7/95	11/98	40	L/L(1.6)	L/L(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	7	93
				7/95	11/99	52	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	**	**
				7/95	10/00	63										
58	22-06-0042	US84	1.35	8/95	11/98	39	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	18	82
				8/95	11/99	51	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	0.35(3.0)	N(0.1)	Good(3.0)	20	80
				8/95	10/00	62	M/H(12.0)	L/L(1.2)	L/L(0.8)	None(0.1)	None(0.1)	0.35(3.0)	N(0.1)	Good(3.0)	20	80

Table B1 (cont'd): Summary of Condition Survey of Micro-surface Projects

DIS	PROJ NO	ROUTE	LENG ft	YEAR CONS mm/yy	YEAR SURV mm/yy	AGE mon	LONG/TRAN CRACKING Sev/Ext	ALLIGATOR CRACKING Sev/Ext	EDGE CRACKING Sev/Ext	POTHOLE/ PATCH Sev/Ext	BLEEDING	RUTTING, in	AGG LOSS	ROUGHNESS	TDP	PCI
61	60-02-0029	LA67	4.55	8/95	12/97	28	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	8	92
				8/95	12/98	40	L/H(4.0)	None(0.15)	L/M(1.6)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				8/95	12/99	52	L/H(4.0)	L/L(0.15)	L/M(1.6)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
				8/95	10/00	62	L/H(4.0)	L/L(0.15)	L/M(1.6)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	10	90
62	260-07-0016	LA43	4.94	9/95	12/97	27	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	14	86
				9/95	12/98	39	M/H(12.0)	L/M(7.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	30	70
				9/95	12/99	51	M/H(12.0)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	24	76
				9/95	10/00	61	M/H(12.0)	L/L(1.2)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Fair(9.0)	24	76
62	261-03-0015	LA22	5.12	9/95	12/97	27	M/M(9.6)	None(0.15)	None(0.1)	None(0.1)	None(0.1)	<0.25(1.8)	N(0,1)	Good(3.0)	14	86
				9/95	12/88	39	M/M(9.6)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	15	85
				9/95	12/99	51	M/M(9.6)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	15	85
				9/95	10/00	61	M/H(12.0)	None(0.15)	L/L(0.8)	None(0.1)	None(0.1)	<0.25(1.0)	N(0.1)	Good(3.0)	17	83
62	848-15-0005	LA3188	2.11	12/95	12/97	24	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	11	89
				12/95	12/98	36	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	11	89
				12/95	12/99	48	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	<0.25(1.0)	N(0.1)	Good(3.0)	11	89
				12/95	02/01	62	L/M(3.2)	None(0.15)	None(0.1)	None(0.1)	L/L(3.6)	.30(3.0)	N(0.1)	Good(3.0)	16	84

Table B2 - Preconstruction Condition Rating of Micro-Surface Sections

DIST	PROJ_NO	RUT1	RUT RATE	IRI1	IRI RATE	RANDOM CRACK	RANDOM CRACK RATE	ALLIG CRACK	ALLIG CRACK RATE	AGE6	PCI6	DIFF IN PCI	RATE OF CHANGE	CRKRATE
2	018-01-0026	0.24	1	174	2	3946	3	451	1	69	82	18	0.26087	3
2	148-01-0023	0.30	2	186	3	3327	3	1206	2	.	.	.	.	3
2	410-02-0014	0.25	1	182	3	305	1	0	1	64	83	17	0.26563	1
2	410-01-0026	0.25	1	126	2	953	2	0	1	64	83	17	0.26563	2
2	826-38-0007	0.21	1	160	2	1007	2	0	1	48	86	14	0.29167	2
2	424-08-0023	0.37	2	179	3	2342	3	579	1	48	87	13	0.27083	3
2	855-04-0051	.	1	.	1	.	1	.	1	61	85	15	0.24590	1
3	828-12-0011	0.31	2	138	2	48	1	1034	2	41	86	14	0.34146	2
3	380-04-0012	0.30	2	171	2	0	1	264	1	53	75	25	0.47170	1
4	010-05-0029	.	1	.	1	.	1	.	1	63	80	20	0.31746	1
5	051-04-0015	0.31	2	137	2	0	1	1183	2	46	92	8	0.17391	2
5	071-01-0022	0.24	1	88	1	13	1	0	1	64	92	8	0.12500	1
5	451-07-0049	0.35	2	84	1	350	1	69	1	50	92	8	0.16000	1
5	069-02-0018	0.33	2	144	2	1760	3	0	1	45	89	11	0.24444	3
7	200-01-0002	0.21	1	131	2	1025	2	552	1	46	90	10	0.21739	2
7	193-31-0022	0.54	3	107	2	13	1	36	1	62	92	8	0.12903	1
8	015-03-0021	.	1	.	1	.	1	.	1	61	84	16	0.26230	1
8	025-02-0031	0.20	1	92	1	404	1	31	1	62	82	18	0.29032	1
58	026-03-0029	0.50	2	124	2	0	1	0	1	.	.	.	.	1
58	022-06-0042	0.50	2	109	2	258	1	344	1	62	80	20	0.32258	1
61	060-02-0029	.	1	.	1	.	1	.	1	62	90	10	0.16129	1
62	260-07-0016	0.19	1	134	2	1674	3	65	1	61	76	24	0.39344	3
62	261-03-0015	0.26	2	113	2	880	2	0	1	61	83	17	0.27869	2
62	848-15-0005	0.36	2	157	2	529	2	323	1	62	84	16	0.25806	2

Table B3 - Aggregate Type and Source used on Micro-Surface projects

OBS	Project Number	Material Code	Material Description	Purp Code	Spec Code	Pass Fail	Date Sampled	Source Code	Description of Source Code
1	010-05-0029	446	STONE (SANDSTONE)	3	1	0	06/21/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
2	010-05-0029	446	STONE (SANDSTONE)	3	1	0	06/21/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
3	015-03-0021	446	STONE (SANDSTONE)	3	1	0	07/28/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
4	015-03-0021	446	STONE (SANDSTONE)	3	1	0	08/03/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
5	015-03-0021	446	STONE (SANDSTONE)	3	1	0	08/03/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
6	018-01-0026	434	SILICEOUS LIMESTONE	3	1	0	11/22/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
7	022-06-0042	446	STONE (SANDSTONE)	3	1	1	06/23/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
8	022-06-0042	446	STONE (SANDSTONE)	3	1	1	07/02/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
9	022-06-0042	446	STONE (SANDSTONE)	3	1	1	07/06/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
10	025-02-0031	446	STONE (SANDSTONE)	3	1	0	07/17/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
11	025-02-0031	446	STONE (SANDSTONE)	3	1	1	07/17/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
12	025-02-0031	446	STONE (SANDSTONE)	3	1	1	07/17/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
13	025-02-0031	446	STONE (SANDSTONE)	3	1	0	07/17/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
14	025-02-0031	446	STONE (SANDSTONE)	3	1	0	07/25/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
15	025-02-0031	446	STONE (SANDSTONE)	3	1	0	07/25/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
16	026-03-0029	446	STONE (SANDSTONE)	3	1	1	06/16/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
17	026-03-0029	446	STONE (SANDSTONE)	3	1	1	06/16/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
18	026-03-0029	446	STONE (SANDSTONE)	3	1	1	06/19/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
19	026-03-0029	446	STONE (SANDSTONE)	3	1	1	06/19/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
20	026-03-0029	446	STONE (SANDSTONE)	3	1	1	06/19/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
21	026-03-0029	446	STONE (SANDSTONE)	3	1	1	06/19/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
22	051-04-0015	446	STONE (LIMESTONE)	3	1	0	09/20/96	A056	TOWER ROCK CO.(ST.GEN.,MO.) COLUMBIA, IL.
23	051-04-0015	446	STONE (LIMESTONE)	3	1	0	09/20/96	A056	TOWER ROCK CO.(ST.GEN.,MO.) COLUMBIA, IL.
24	051-04-0015	446		3	1	0	10/17/96	9999	
25	051-04-0015	446		3	1	0	10/17/96	9999	
26	060-02-0029	434		3	1	0	06/30/95	9999	
27	148-01-0023	434	SILICEOUS LIMESTONE	3	1	0	11/19/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
28	193-31-0022	446	STONE (SANDSTONE)	3	4	0	08/24/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
29	193-31-0022	446	STONE (SANDSTONE)	3	4	0	08/25/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
30	193-31-0022	446	STONE (SANDSTONE)	3	1	0	08/26/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
31	193-31-0022	446	STONE (SANDSTONE)	3	1	0	08/27/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
32	193-31-0022	446	STONE (SANDSTONE)	3	1	0	08/28/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
33	193-31-0022	446	STONE (SANDSTONE)	3	1	0	08/29/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
34	193-31-0022	446	STONE (SANDSTONE)	3	1	0	09/06/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
35	193-31-0022	446	STONE (SANDSTONE)	3	1	0	09/07/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
36	193-31-0022	446	STONE (SANDSTONE)	3	1	0	09/08/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
37	193-31-0022	446	STONE (SANDSTONE)	3	1	0	09/10/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
38	193-31-0022	446	STONE (SANDSTONE)	3	1	0	09/11/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
39	260-07-0016	446	STONE (SANDSTONE)	2	1	1	08/01/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
40	260-07-0016	446	STONE (SANDSTONE)	2	3		08/01/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
41	260-07-0016	446	STONE (SANDSTONE)	3	1	0	08/07/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
42	260-07-0016	446	STONE (SANDSTONE)	3	1	1	08/07/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
43	260-07-0016	446	STONE (SANDSTONE)	3	1	1	08/07/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
44	260-07-0016	446	STONE (SANDSTONE)	3	1	1	08/07/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
45	260-07-0016	446	STONE (SANDSTONE)	3	1	0	08/07/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
46	260-07-0016	446		3	1	1	07/20/95	9999	
47	261-03-0015	446	STONE (SANDSTONE)	2	1	0	07/24/95	AA51	MERIDIAN (SAWYER, OK) POWDERLY, TX
48	261-03-0015	446		3	1	1	07/27/95	9999	
49	261-03-0015	446		3	1	1	07/27/95	9999	
50	380-04-0012	446	CALERA, AL	3	1	0	01/12/96	0736	BLUE CIRCLE CEMENT(ROBERTA PL) I, IB
51	410-01-0026	434	STONE (SANDSTONE)	3	1	0	08/15/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
52	410-01-0026	434	STONE (SANDSTONE)	3	1	0	09/10/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
53	410-01-0026	434	STONE (SANDSTONE)	3	1	0	09/12/95	AA66	MARTIN MARIETTA AGG.(CAVE-IN ROCK) NEW ORLEANS,LA
54	424-08-0023	434	SILICEOUS LIMESTONE	3	1	0	12/09/96	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY

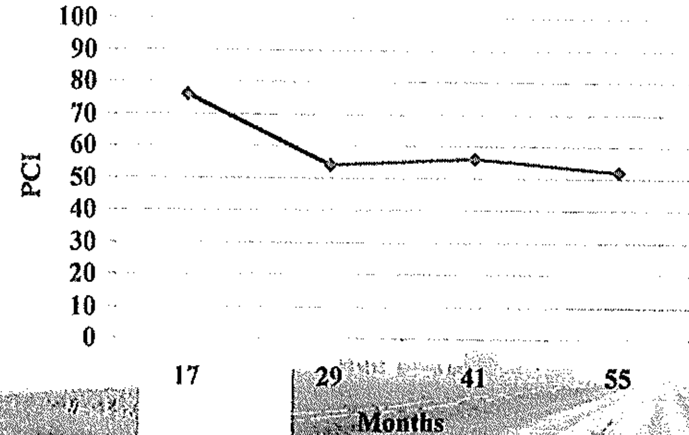
Table B3(cont'd) - Aggregate Type and Source used on Micro-Surface Projects

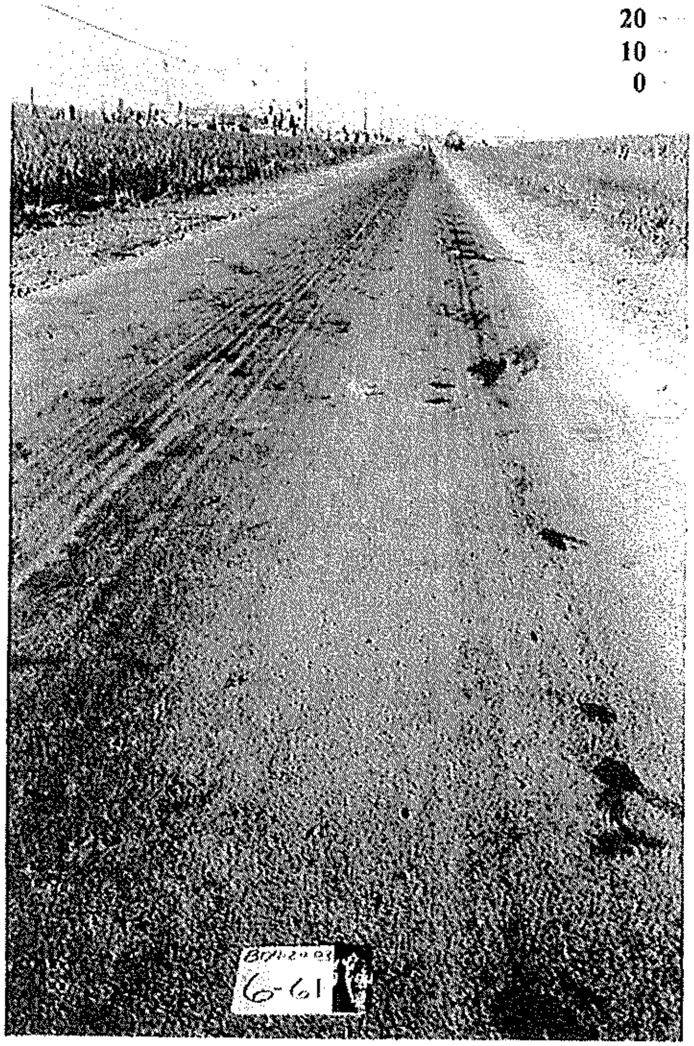
OBS	Project Number	Material Code	Material Description	Purp Code	Spec Code	Pass Fail	Date Sampled	Source Code	Description of Source Code
55	424-08-0023	434	SILICEOUS LIMESTONE	3	1	0	12/09/96	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
56	424-08-0023	434	SILICEOUS LIMESTONE	3	1	0	12/09/96	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
57	424-08-0023	434	SILICEOUS LIMESTONE	3	1	0	12/09/96	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
58	451-07-0049	446	STONE (LIMESTONE)	3	1	0	04/11/96	A037	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
59	451-07-0049	446	STONE (LIMESTONE)	3	1	0	04/11/96	A037	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
60	451-07-0049	446	STONE (LIMESTONE)	3	1	0	04/11/96	A037	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
61	451-07-0049	446	STONE (LIMESTONE)	3	1	0	04/11/96	A037	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
62	451-07-0049	446	STONE (LIMESTONE)	3	1	0	04/11/96	A037	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
63	451-07-0049	446	STONE (LIMESTONE)	3	1	0	04/11/96	A037	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
64	848-15-0005	446	SILICEOUS LIMESTONE	3	1	0	11/09/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
65	848-15-0005	446	SILICEOUS LIMESTONE	3	1	0	11/09/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
66	848-15-0005	446	SILICEOUS LIMESTONE	3	1	0	11/13/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
67	848-15-0005	446	SILICEOUS LIMESTONE	3	1	0	11/13/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY
68	855-04-0051	446	SILICEOUS LIMESTONE	3	1	0	12/06/95	AA50	VULCAN MATLS.CO. (REED QUARRY) GILBERTSVILLE, KY

APPENDIX C

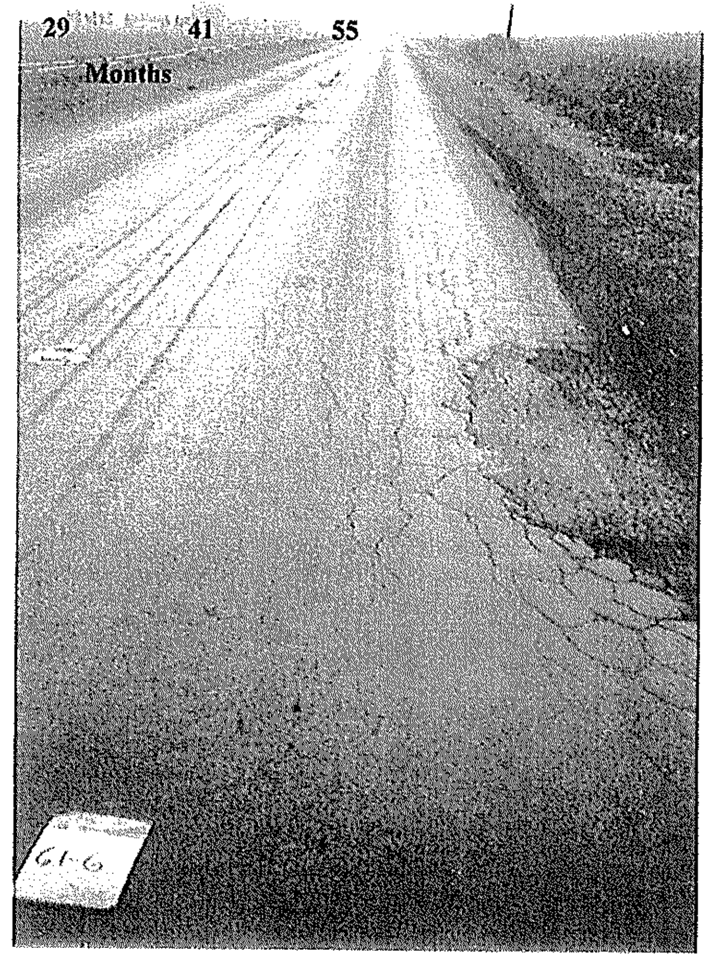
Photographs of chip seal projects

LA 999 Chip Seal





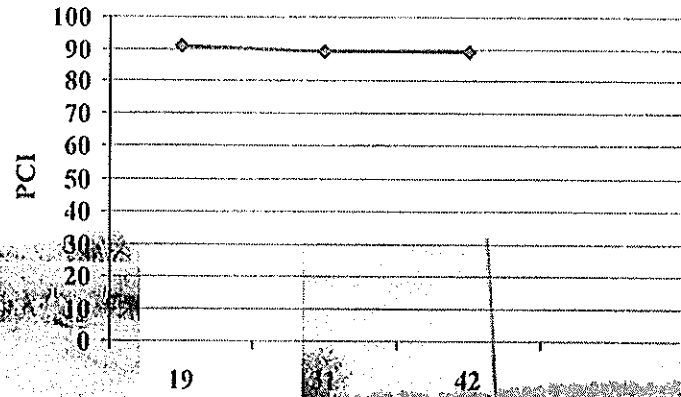
December 1998

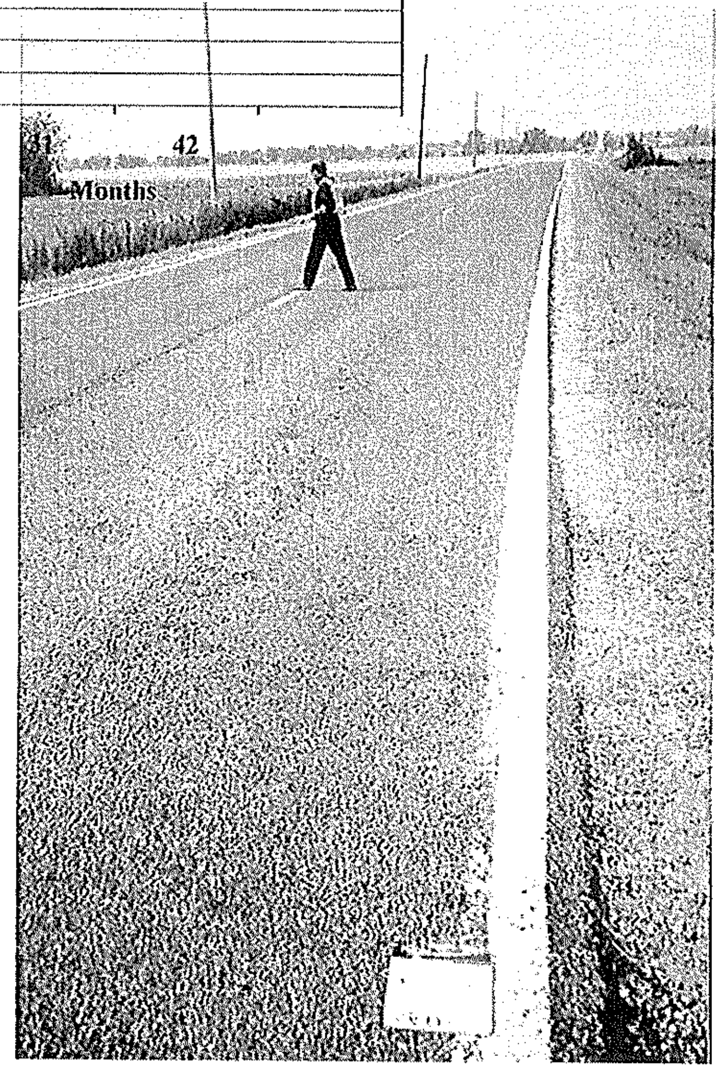


February 2001

LA 4 Chip Seal

November 1998



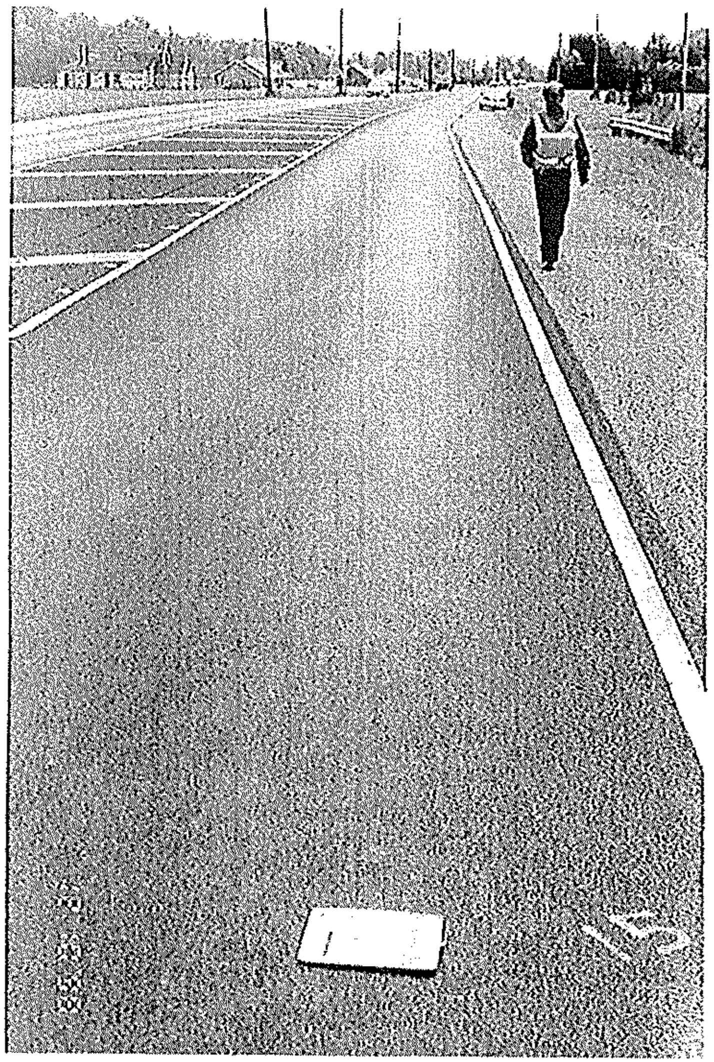


February 2001

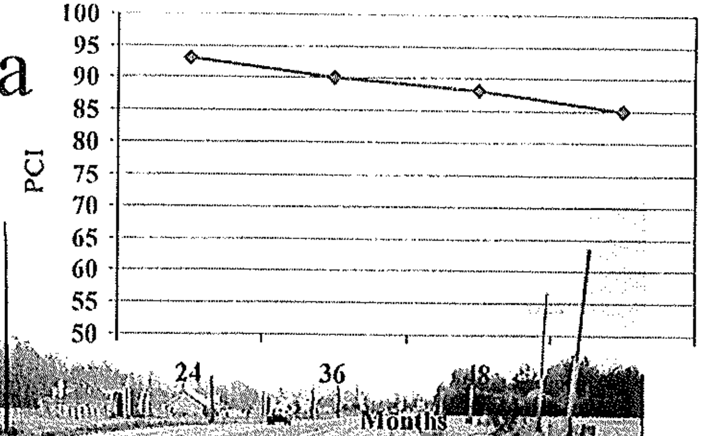
APPENDIX D

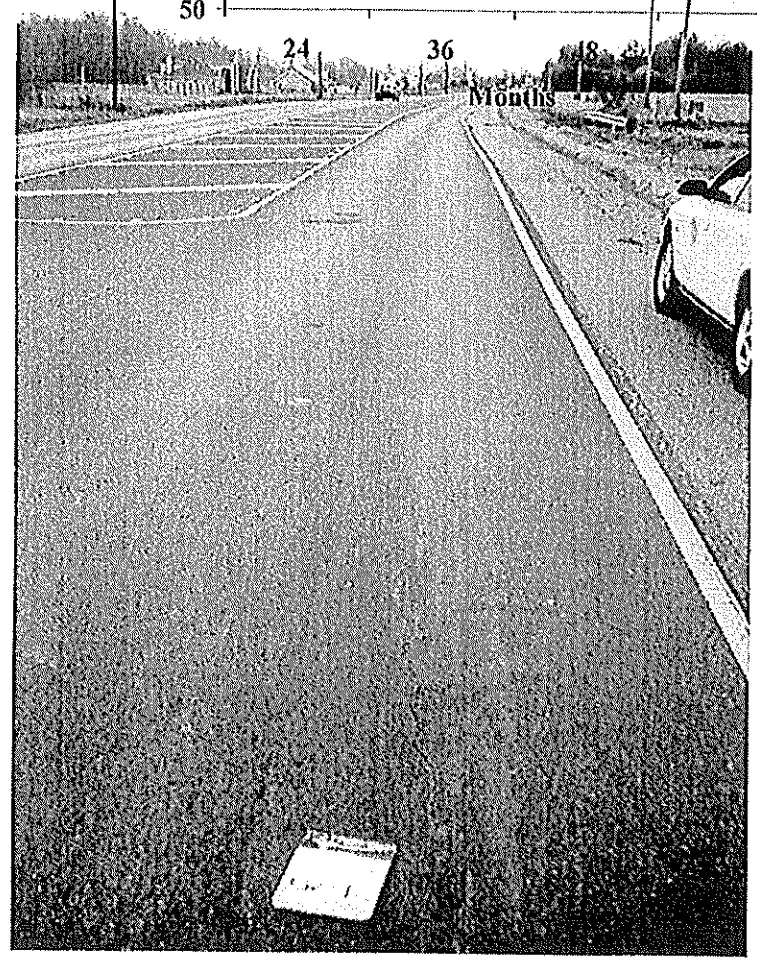
Photographs of micro-surface projects

LA 659 Micro Surfacing, Houma



December 1998

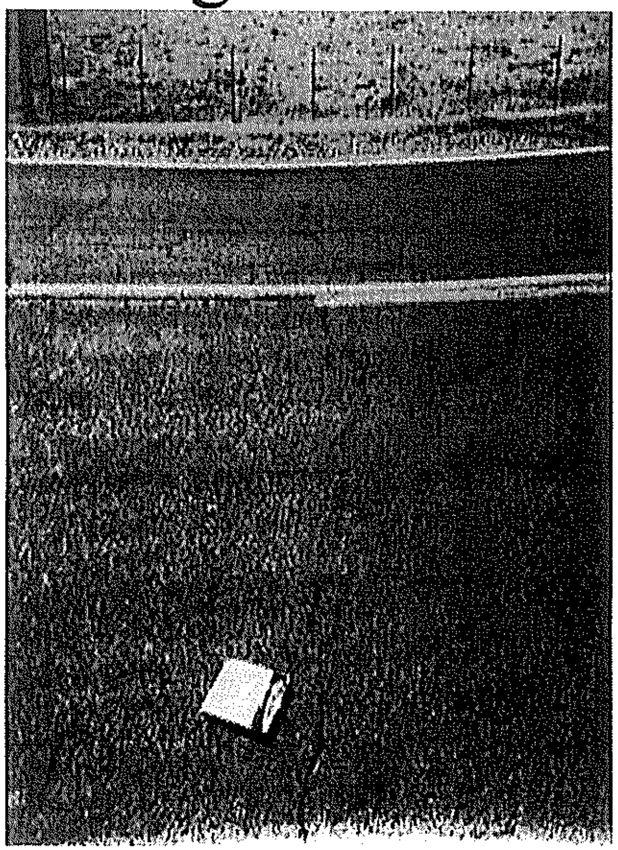




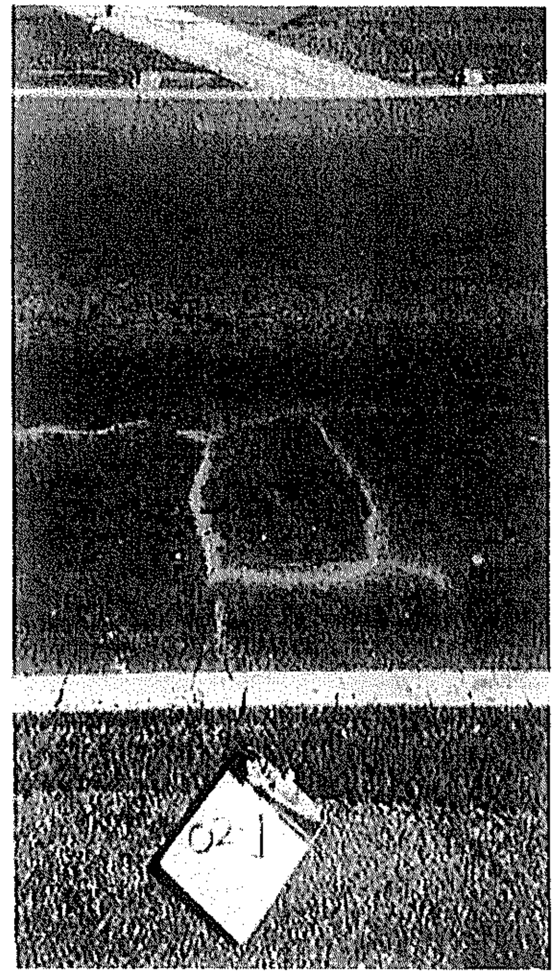
February 2001

Microsurfacing Distresses: Cracking

Alligator



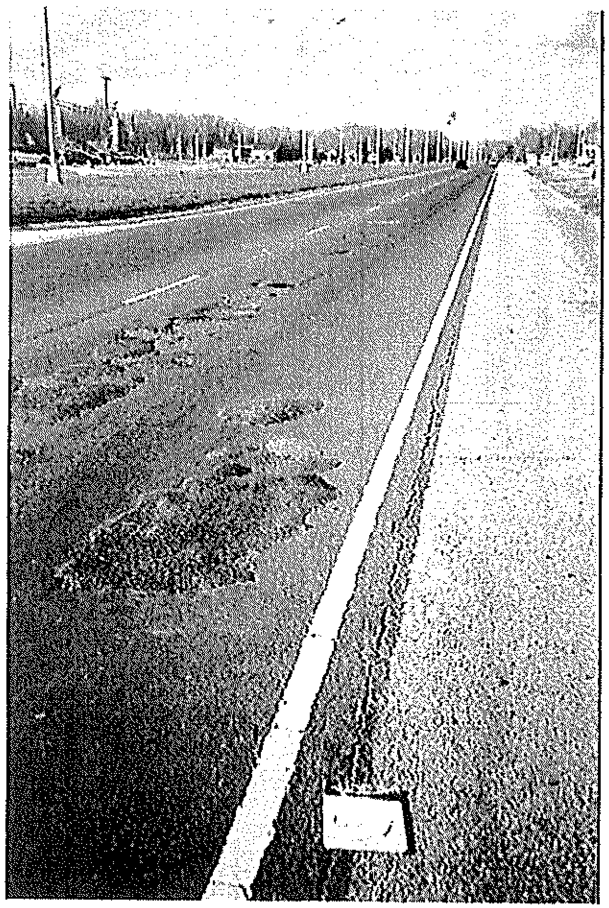
Longitudinal/Transverse



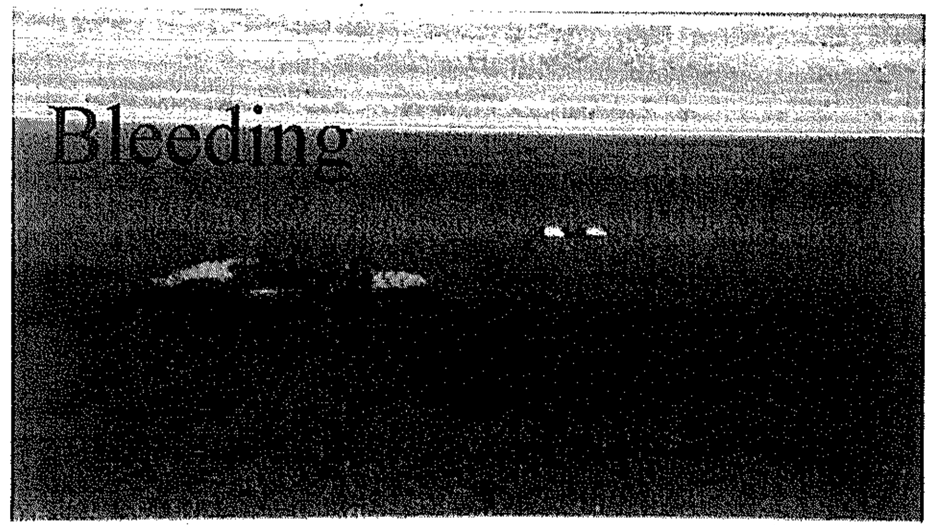
Edge (Widening)

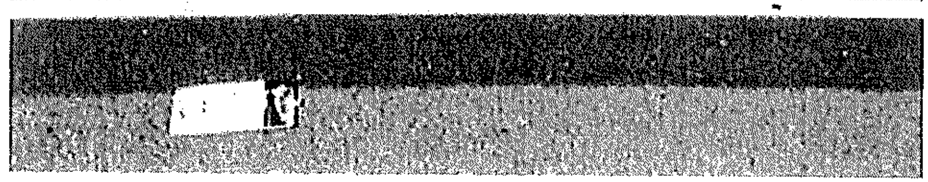
Microsurfacing Distresses:

Patch/ Pothole



Bleeding





Aggregate Loss

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