Maintenance and Rehabilitation

Field Performance of Micro Surfacing Treatments for Pavement Preservation

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Abstract

Micro surfacing is a pavement preservation treatment that can be used to protect the pavement structure from moisture and correct minor surface defects. As with other preservation treatments, performance of treated sections depends in great part on proper candidate selection and timely intervention. Estimates for pavement life extension typically range from 3 to 7 years; however, the criteria for defining performance varies among sources. As part of the National Center for Asphalt Technology (NCAT) and the Minnesota Department of Transportation Road Research Facility (MnROAD) Pavement Preservation Study, micro surfacing test sections were placed on both low and high traffic volume roads in Auburn, Alabama. Test sections include single, double and cape seal applications, and have been monitored periodically to assess structural condition, surface distress and ride quality. The overall objective of the study is to determine the life-extending benefit of several pavement preservation treatments as a function of traffic, climate and existing pavement condition. This paper describes the observed performance of a subset of test sections located in the southern region of the United States, characterized for its hot, wet, no-freeze environment. The results showed that micro surface application can significantly extend the life of the pavement compared to the untreated sections. The Pavement Preservation Study is still underway, and data collection efforts continue to develop final performance models. The long-term results are expected to provide valuable information that will help agencies estimate the performance of their treated pavement more accurately according to their local conditions.

This paper was first published in 2020 in version 1.0 of the proceedings of the 7th E&E Congress. This second edition (version 1.1.) of the proceedings is published in June 2021. The content of this paper has not changed, but the author(s) may have provided additional information in the form of an annex.

1. INTRODUCTION

Micro surfacing refers to a mixture of polymer-modified emulsified asphalt, mineral aggregate, water, and additives, proportioned, mixed and uniformly spread over a properly prepared surface [1]. This pavement preservation treatment can be used to address minor distresses, correct ruts, improve surface texture, enhance ride quality, and ultimately extend pavement life [2].

As with other preservation treatments, performance of treated sections depends in great part on proper candidate selection and timely intervention, although, when used in cape seals, long-term performance may be less sensitive to the condition of the existing pavement [3]. Other factors such as traffic loading, environmental conditions, material quality and mix design, and construction quality can also significantly affect treatment performance [4]. Estimates for pavement life extension typically range from 3 to 7 years; however, the criteria for defining performance varies among sources [5]. Service life extension is usually estimated based on rutting or roughness; nonetheless, micro surfacing has also shown to slow the progress of reflective cracking [6].

2. OBJECTIVES AND SCOPE OF WORK

The objective of this study was to evaluate the field performance of micro surfacing test sections placed on two roads with different levels of traffic. To accomplish this objective, full-scale test sections were treated with micro surfacing applications and their performance monitored periodically over time.

3. METHODOLOGY

3.1. Pavement Preservation Study

The Pavement Preservation Group (PG) study began in the summer of 2012 as part of the National Center for Asphalt Technology (NCAT) fifth research cycle, in response to the need for a better assessment of pavement preservation performance that would allow agencies to make objective decisions regarding treatment selection. The initial research effort consisted of placing various preservation treatments on a low volume county road in Auburn, Alabama, and monitoring their performance.

Based on the preliminary findings from 2012, the study was expanded in the 2015 research cycle by placing an extended version of the pavement preservation treatments/combinations on a high traffic roadway in Alabama. Additionally, in an effort to provide results that are practical and implementable in both northern and southern US climates, NCAT partnered with the Minnesota DOT's Road Research Facility (MnROAD). In 2016, a number of the PG study treatments were replicated on low and high volume roadways near Pease, Minnesota.

3.2. Treatment Description

This paper describes the observed performance of micro surfacing test sections located in the southern region of the experiment, characterized for its hot, wet, no-freeze environment. The two locations were selected to represent low and high levels of traffic. Lee Road 159 (LR-159) is a county road with a low traffic volume but a high percentage of truck traffic, as it provides dead-end access to a quarry and asphalt plant. Conversely, Highway 280 (US-280) is a high traffic U.S. route that runs through east central Alabama. Table 1 summarizes the characteristics of each location.

Table 1. Characteristics of test locations

Roadway	**LR-159**	**US-280**
Location	Auburn, AL	Opelika, AL
Direction	Both lanes	Westbound truck lane
Test section length, ft	100	528
Existing average bituminous layer thickness, in	5.5	9.9
Year treated	2012	2015
Accumulated ESALs (as of January 2019)	74,000 (inbound) 1,000,000 (outbound)	2,000,000

This paper focuses on treatments that can be classified as a variation of a micro surface, either as a single or double layer, or as the wearing surface in a cape seal. On LR-159 all micro surfaces were Type II and used a granite aggregate source, while the treatments on US-280 were Type III and used a sandstone aggregate, with the exception of the double layer limestone micro surface. Table 1 provides a description of each test section.

Table 2. Treatment description

Treatment	Description	LR-159	US-280
Single micro surface	Single layer micro surface	✓	✓
Micro surface with crack seal	Single layer micro surface placed after crack sealing	✓	✓
Double micro surface	Double layer micro surface (limestone)	✓	✓
Double micro surface	Double layer micro surface (sandstone)	NA	✓
Cape seal	Single layer micro surface placed over single layer chip seal	✓	✓
Fibermat cape seal	Single layer micro surface placed on fiber membrane reinforced chip seal	✓	✓
Scrub cape seal	Single layer micro surface placed over scrub seal	✓	✓
Micro surface with fibers	Single layer micro surface incorporating fibers	NA	✓
HiMA micro surface	Single layer micro surface with high polymer modified emulsion	NA	✓

NA: Treatment not applied in this location

3.3. Data Collection

Performance data were obtained using a data collection vehicle equipped with an inertial profiler, laser systems, and high-resolution cameras. The inertial profiler collects the longitudinal profile of the pavement surface for both wheel paths. These profiles are used to measure the roughness of the pavement in terms of the international roughness index (IRI). Dual scanning lasers can obtain the transverse profile and measure rut depths. Finally, the images obtained with the high-resolution cameras are processed to assess the extent of detected cracking.

The condition of the pavement structure was evaluated by means of the falling weight deflectometer (FWD) in accordance to ASTM D 4694. FWD data were collected at two random locations per test section. At each location, testing was performed in the inside, outside and between wheelpaths, in the inbound and outbound directions. A Dynatest 8000 FWD was used with nine sensors spaced at 0, 8, 12, 18, 24, 36, 48, 60 and 72 inches from load center and a load plate with a radius of 5.91 inches. At the time of testing, three repetitions at four load levels (approximately 6, 9, 12 and 16 kips) were completed at each location and surface temperatures were recorded.

4. RESULTS AND DISCUSSION

4.1. Surface Distress

The main type of distress observed in the test sections has been cracking, particularly in LR-159 where test sections have been in place for a longer time, as seen in Figure 1. In the low traffic location, the sections can be separated into three groups based on performance: untreated, single layer applications, and multi-layer or cape seal applications. As expected, more robust treatments have resulted in improved cracking resistance. In the case of high traffic volume sections in US-280, a clear distinction among treatments cannot be observed yet, and all sections exhibit 10% cracking or less.

To provide a fair assessment of treatment performance, it is important to take into account the condition of the pavement at the time of application. For treatments that were placed in both locations, Figure 2 shows the total cracking percentages prior to treatment application, and after 3 and 6 years of service. In the low traffic location, all treatments clearly outperform the control sections, which have deteriorated rapidly. The treated sections have been effective in slowing the reappearance of cracking in the pavement surface, with the double layer and most cape seal applications still under their pretreatment cracking level. In addition, the benefit of combining micro surfacing with crack sealing can also be observed. While the single layer micro surfaces with and without crack sealing appear to have similar performance in Figure 2, it should be noted that the section which included crack sealing exhibited a significantly higher amount of pretreatment cracking.

Conversely, all sections in the high traffic location have exceeded their pretreatment cracking level after three years of service. However, the amount of cracking present prior to treatment application was low (7% or less). Continued performance monitoring over the upcoming years will determine if the trends observed in LR-159 are also observed under increased traffic conditions.

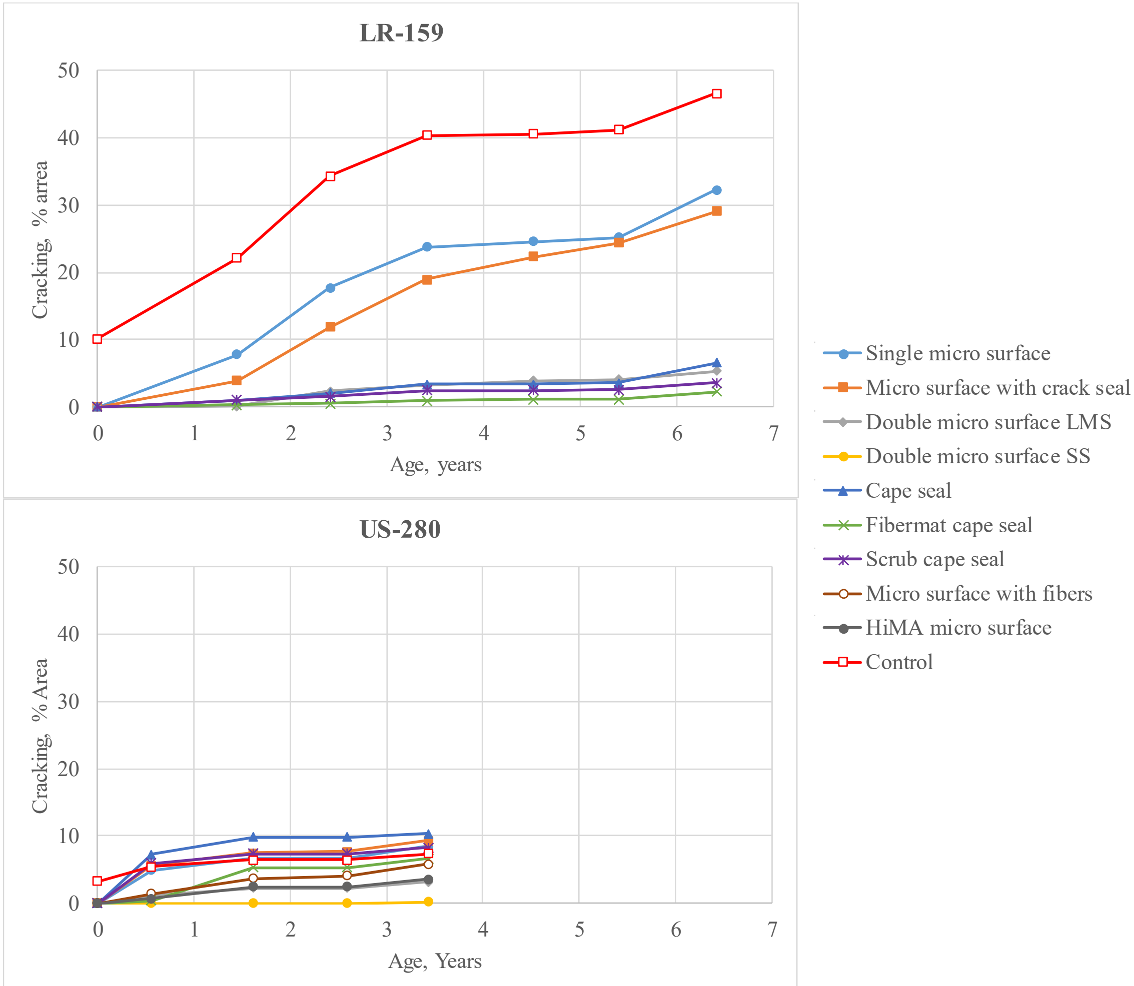


Figure 1: Cracking progression in test locations

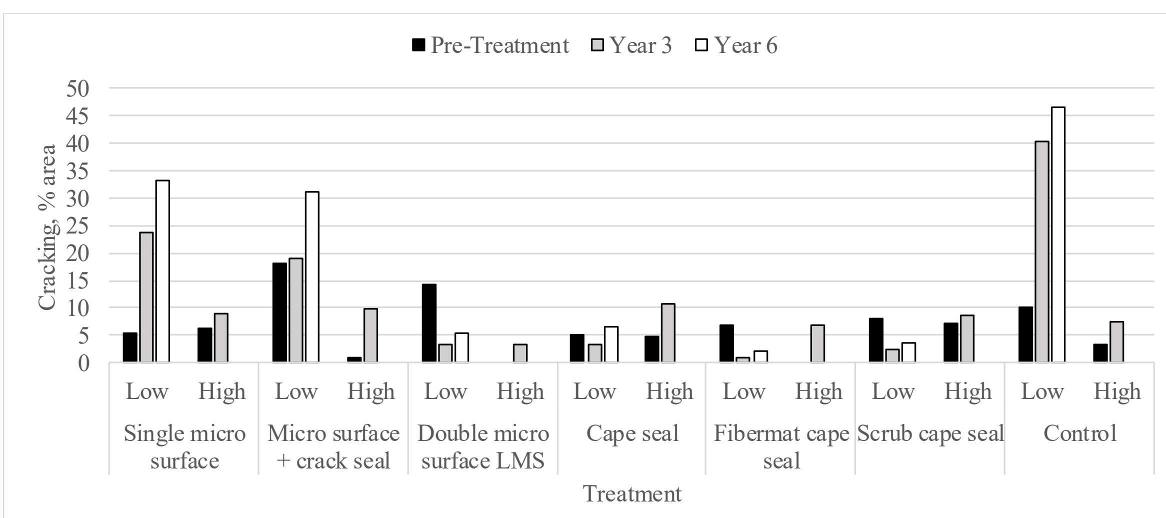


Figure 2: Cracking performance in low and high traffic test sections

Rutting and roughness are also periodically monitored as part of the Pavement Preservation Group Study. Micro surfacing is one of the treatments that has the capability to address minor rutting and restore ride quality [7, 8]. The test sections included in this study exhibited low levels of rutting and IRI prior to treatment application, making them suitable candidates for pavement preservation.

Figure 3 shows the average section rut depths over time. It can be seen that there has been little variation during the time the treatments have been in service, and that the rutting condition remains generally good (under 5 mm) in the low traffic volume sections, and good to fair (under 10 mm) in the high traffic volume sections. There is not a clear difference in performance among treatments, but cape seals and double layers tend to have lower rutting levels. However, since the values are low, the differences observed are not of practical significance at this point in the research.

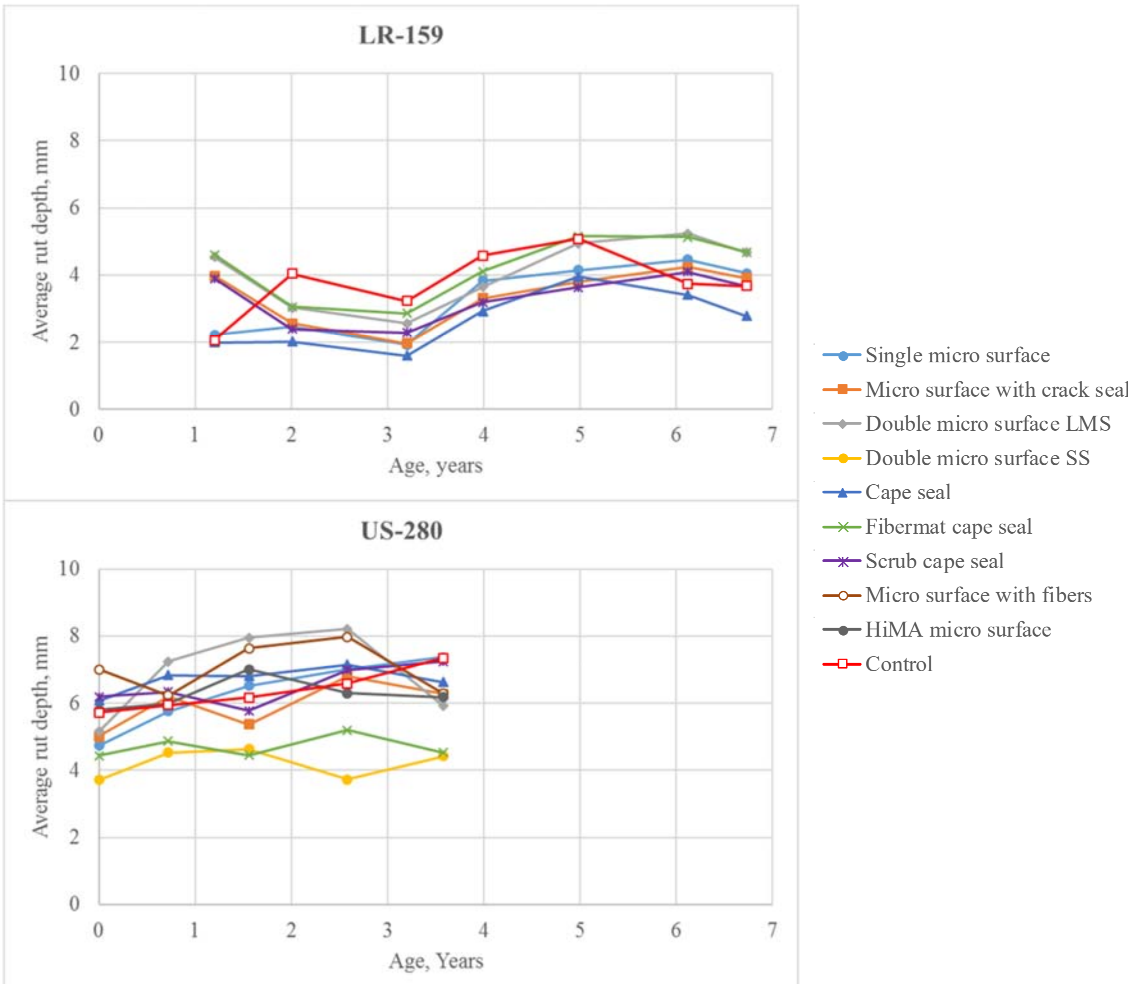


Figure 3: Rutting progression in test locations

Roughness (by means of IRI) over time is presented in Figure 4. In the LR-159 sections where traffic volume is low, the IRI values have remained nearly constant over more than six years of service. The single layer micro surfacing section exhibits an irregular behaviour due to a main water line rupture that resulted in a localized distress area that had to be patched multiple times before the ride quality was restored. Overall, the roughness condition is considered good (under 95 in/mi). In the case of the high traffic sections in US-280, a slight upward trend can be observed; however, the average annual increase in IRI is 2.3 in/mi, which can be considered within a normal rate of deterioration.

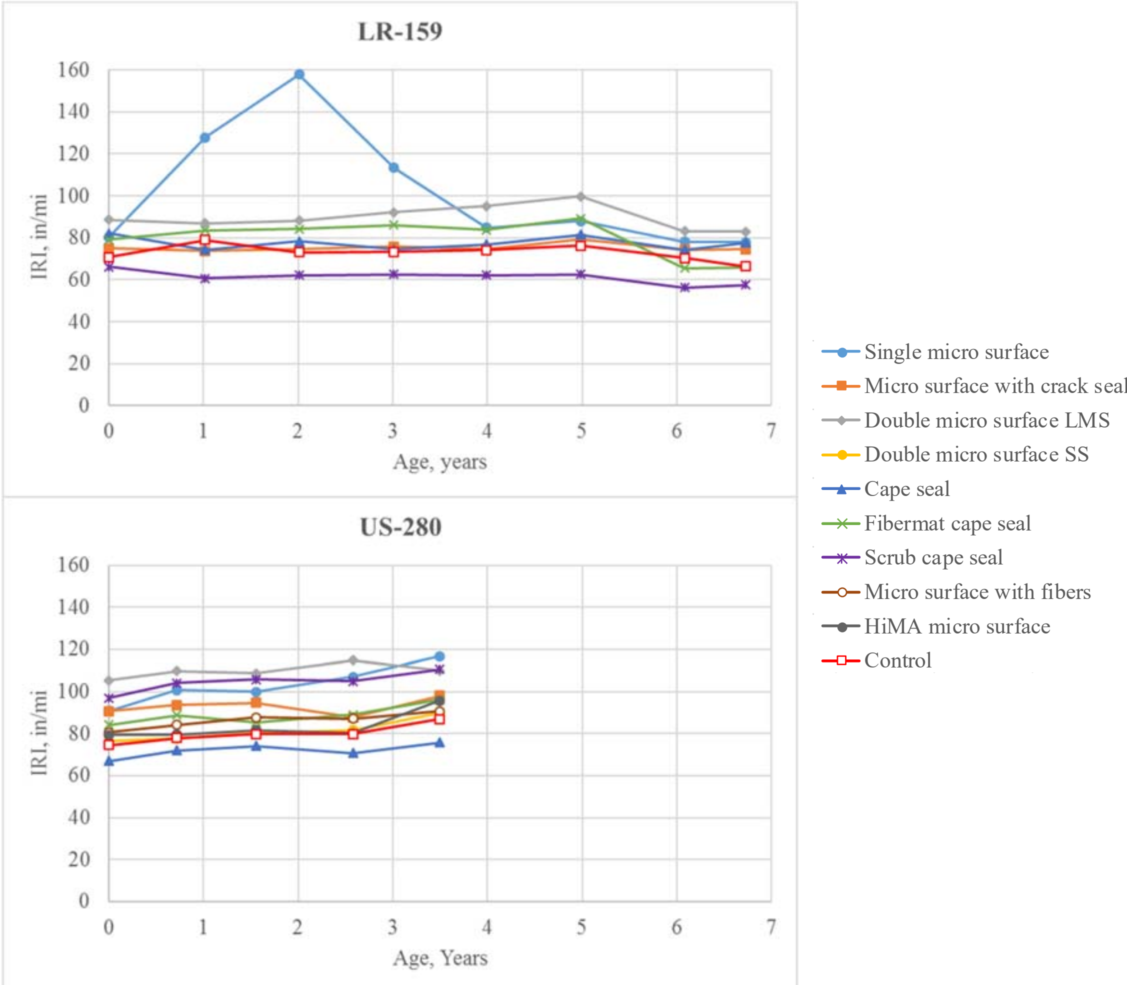


Figure 4: IRI progression in test locations

4.2. Structural Condition

Although micro surfacing treatments are not expected to provide a significant improvement, the structural condition of the test sections was periodically monitored to determine the effectiveness of the treatments in maintaining the pavement structure in sound condition. FWD deflections recorded were used to calculate deflection basin parameters (DBPs) that characterize the structural condition of the various pavement layers. In this study, three DBPs were considered: the Area Under the Pavement Profile (AUPP), the Base Damage Index (BDI) and the Base Curvature Index (BCI), as shown in Table 3.

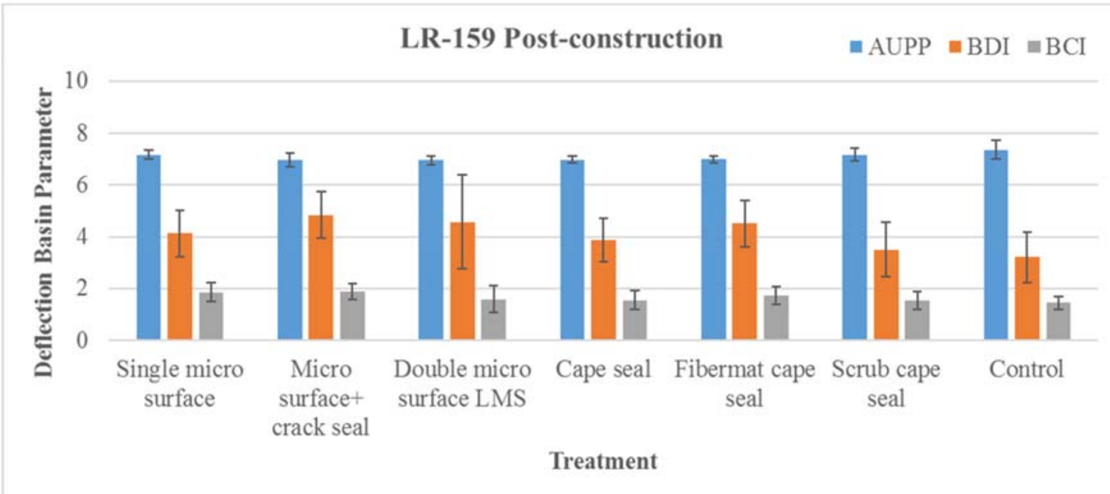
Table 3. Deflection Basin Parameters

Parameter	Equation	Layer Characterized
Area under pavement profile	$AUPP = \frac{5D_0+2D_{12}+2D_{24}+D_{36}}{D_0}$	Upper layers
Base Damage Index	$BDI = D_{12} - D_{24}$	Base
Base Curvature Index	$BCI = D_{24} - D_{36}$	Subbase or subgrade

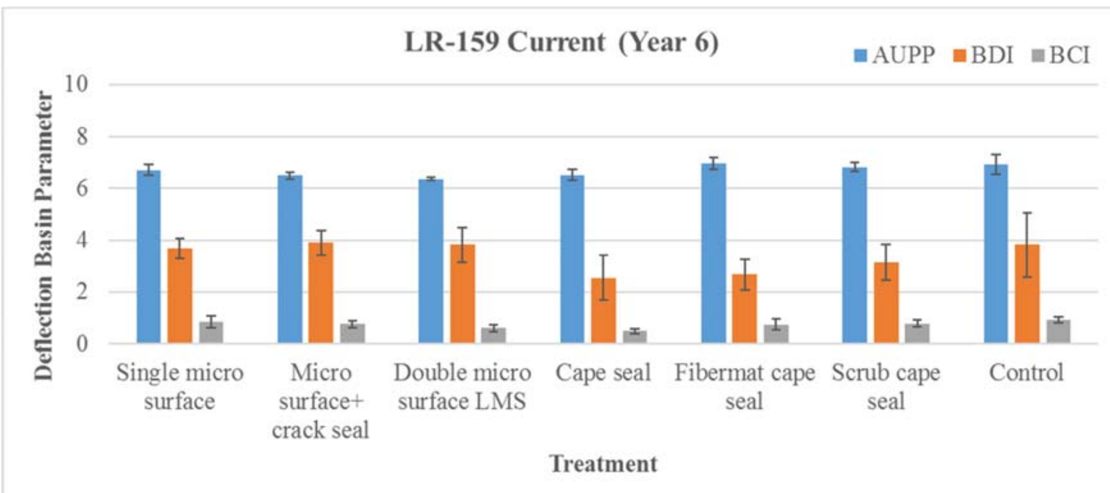
D_0, D_{12}, D_{24}, and D_{36} are the measured deflections at a distance of 0, 12, 24 and 36 inches from the center of the loading plate, respectively.

The AUPP parameter correlates with the horizontal tensile strain at the bottom of the asphalt concrete layer. Higher AUPP values indicate higher strains, and therefore a higher potential for bottom-up fatigue cracking. The BDI and BCI indices represent the structural condition of the base and subgrade layers, respectively. Higher values indicate more damage in the structure.

Figures 5 and 6 show the deflection basin parameters for the low and high traffic volume sections, respectively. In each case, DBP values obtained immediately after treatment application (post-construction) and at the current time are presented. In general, no significant changes have been observed from the time the treatments were placed and through the period they have been in service. The pavement structure remains in sound condition in both locations, with low DBP values.

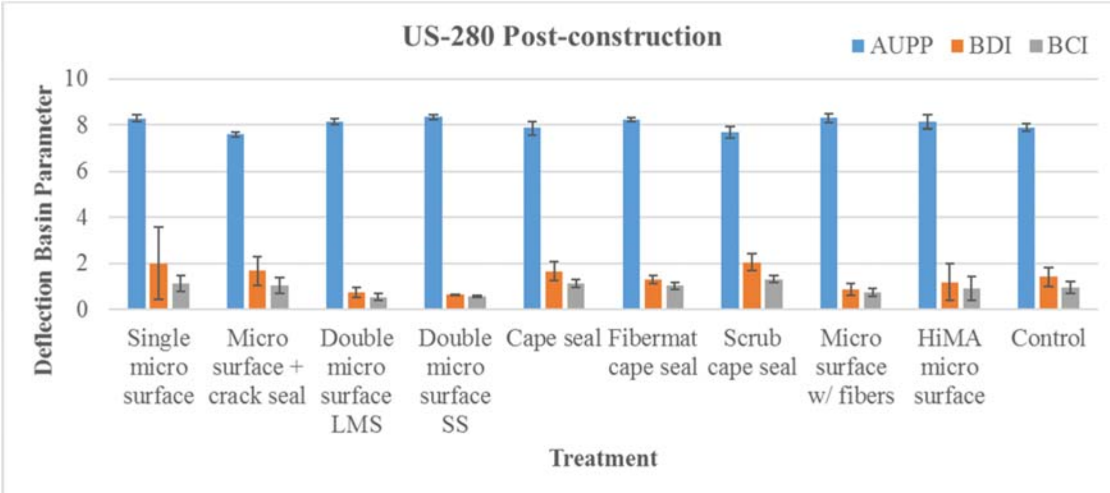


(a)



(b)

Figure 5: Deflection basin parameters in low traffic volume sections a) post-construction and b) after 6 years of service



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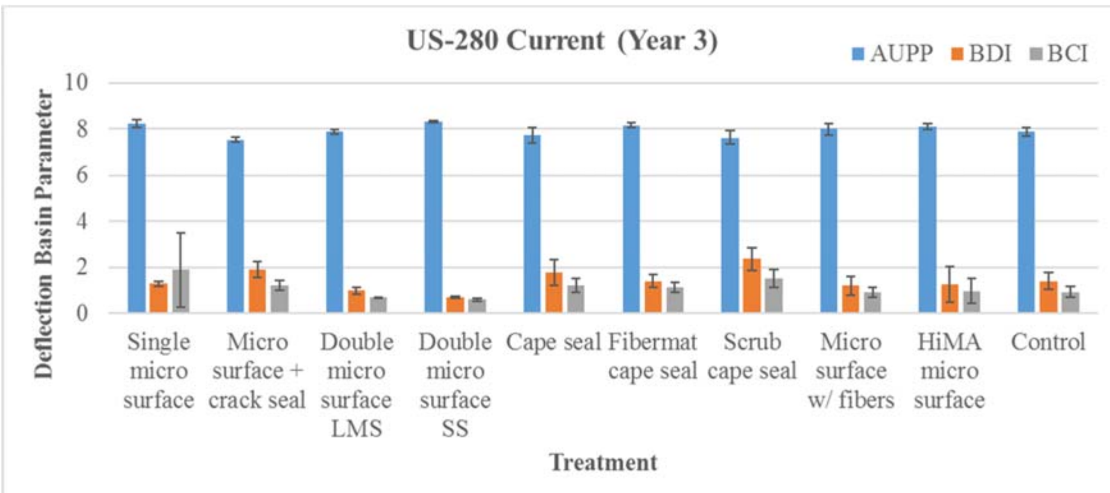

(b)

Figure 6: Deflection basin parameters in high traffic volume sections a) post-construction and b) after 6 years of service

4.3. Cluster Analysis

Given the number of performance indicators that are collected as part of the condition assessment, a cluster analysis was performed to incorporate all variables in the evaluation and obtain insight on the performance of the different treatments. Cluster analysis consists on grouping objects into classes so that there is some similarity between the objects in a given class [9]. There are several methods for measuring the similarity between objects as well as algorithms for sorting objects into groups. This study used the Euclidian distance as the similarity measure and Ward's method for creating the groups.

The analysis was performed separately for each test location, and included the following variables measured at the current time (year 3 for US-280 and year 6 for LR-159): cracking percentage, average rut depth, IRI, AUPP, BDI and BCI. In addition, since cracking has exhibited the most change over time, the cracking percentage prior to treatment application was also included to account for the effect of the existing pavement condition. A maximum of three clusters was selected so that the resulting groups would contain more than one object.

Tables 4 and 5 present the descriptive statistics for each of the clusters in the low and high traffic volume locations, respectively. The results for the LR-159 sections suggest that the first cluster contains the best performing treatments (all cape seals), which exhibit low values for all parameters. The second cluster could be considered to have an intermediate performance, and the third cluster shows more deterioration after six years of service. Although the control sections and the single micro surface were placed in the same cluster, there is considerable variability in the percentage of cracking between the two, with higher cracking in the untreated sections, as seen earlier.

Table 4. Descriptive Statistics of Clusters in LR-159

Parameter	Cluster 1, n=3		Cluster 2, n=2		Cluster 3, n=2	
	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
Treatments	Cape seal, Fibermat cape seal, scrub cape seal		Micro surface with crack seal, double micro surface		Control, single micro surface	
% Cracking (pre-treat.)	6.7	1.5	16.2	2.8	7.8	3.2
% Cracking (current)	4.1	2.2	17.2	16.9	39.4	10.1
Rut depth, mm	3.7	1.0	4.3	0.5	3.9	0.3
IRI, in/mi	67.0	10.2	78.7	5.9	72.1	8.1
AUPP	6.4	0.05	6.3	0.1	6.7	0.1
BDI	4.1	0.4	5.5	0.8	4.7	0.1
BCI	1.1	0.2	1.2	0.1	1.4	0.02

For the US-280 sections (shown in Table 5), the cluster designations are not as clear as in the low traffic volume location. Again, the first cluster appears to be the best performing group, with the lowest amounts of cracking, rutting, BDI and BCI, and intermediate results for IRI and AUPP. The second and third clusters have mixed results; while cluster 2 has the highest amount of cracking, it also has the lowest IRI and intermediate levels of rutting and deflection basin parameters. Conversely, while cluster 3 has an intermediate amount of cracking at year 3, it also had the highest amount prior to treatment application, and on average has the roughest sections. Ranking the performance of the two clusters would depend on which parameter is more relevant for a given condition.

Table 5. Descriptive Statistics of Clusters in US-280

Parameter	Cluster 1, n=5		Cluster 2, n=3		Cluster 3, n=2	
	Avg.	St. Dev.	Avg.	St. Dev.	Avg.	St. Dev.
Treatments	Double micro surface LMS, double micro surface SS, Fibermat cape seal, micro surface with fibers, HiMA micro surface		Control, micro surface with crack seal, cape seal		Single micro surface, scrub cape seal	
% Cracking (pre-treat.)	0.3	0.5	3.0	2.0	6.8	0.8
% Cracking (current)	3.9	2.6	9.0	1.5	8.4	0.1
Rut depth, mm	5.5	0.9	6.7	0.6	7.3	0.1
IRI, in/mi	96.5	8.0	86.9	11.2	113.7	4.2
AUPP	8.1	0.2	7.7	0.2	7.9	0.4
BDI	1.1	0.3	1.7	0.3	1.8	0.8
BCI	0.9	0.2	1.1	0.2	1.7	0.3

5. CONCLUSIONS AND RECOMMENDATIONS

This work evaluated the field performance of micro surfacing test sections placed on two roads with different levels of traffic. The results are part of a broader ongoing long-term study that aims at quantifying the life-extending benefits of several pavement preservation treatments under varying conditions. For a subset a micro surfacing treatments placed on a hot, wet, no-freeze environment and subjected to low and high levels of traffic, the following observations were made:

- Performance of the test sections is mostly characterized by the amount of cracking developed while in service relative to the amount of cracking present prior to treatment application. In the low traffic volume location, which has been in service the longest, all treatments clearly outperform the control sections. For the high traffic volume sections, the observed trends are not clear after three years of service, and all sections have 10% cracking or less.
- Rutting has exhibited little variation during the time the treatments have been in service, and the condition remains generally good (under 5 mm) in the low traffic volume sections, and good to fair (under 10 mm) in the high traffic volume sections. There is not a clear difference in performance among treatments, but cape seals and double layers tend to have lower rutting levels. However, since the values are low, the differences observed are not of practical significance at this point in the research.
- In the low traffic location, IRI values have remained nearly constant over more than six years of service and overall, the roughness condition is considered good (under 95 in/mi). In the case of the high traffic sections,

a slight upward trend can be observed; however, the average annual increase in IRI is 2.3 in/mi, which can be considered within a normal rate of deterioration.

- In the case of the structural condition, no significant variation has been observed since treatment application and the pavement structure remains in sound condition in both locations, with low DBP values.
- A cluster analysis was performed to assess the performance of the treatments based on all the information collected. For test sections subjected to low traffic volume, cape seal treatments are in better overall condition. In the high traffic sections, the cluster designations were not as clear, but the best overall performers included some of the more robust treatments such as double layer applications and a cape seal, as well as enhanced single layer applications that incorporate fibers and high polymer content.

The Pavement Preservation Group Study is still ongoing and data collection effort continue to evaluate the long-term performance of the different treatments. The results are expected to provide valuable information that will help agencies estimate the performance of their treated pavement more accurately according to their local conditions.

ACKNOWLEDGEMENTS

The author thanks the Departments of Transportation of Alabama, Colorado, Georgia, Illinois, Kentucky, Michigan, Minnesota, Mississippi, Missouri, New York, South Carolina, Oklahoma, Tennessee and Wisconsin and FP2 Inc. for their sponsorship and continued support of this project.

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