Performance Analysis of Microsurfacing on Asphalt Pavements and Asphalt Overlays

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ABSTRACT

The ability to monitor long-term performance of pavements has advanced significantly over the past 20 years. Performance monitoring provides quantitative measurements for longitudinal cracking, transverse cracking, fatigue cracking, rutting, friction and roughness and more. Until recently, the influence of asphalt surface treatments on performance has been difficult to quantify. The improved performance data collection has allowed for better quantitative analysis of the influence preservation treatments have on asphalt pavement and asphalt overlay performance. The microsurfacing industry has provided uniform guidance for microsurfacing implementation, helping agencies write specifications. Microsurfacing requires polymer modified asphalts and the enhanced properties have led to improved performance and growing use of innovative surface treatments like microsurfacing. For this study, the performance of twenty-three microsurfacing projects were studied to evaluate the overall effect of microsurfacing on pavement performance and longevity. The combined length all projects represents 336 lane-km of microsurfacing. Seventeen additional projects were constructed in 2015-2016, which will be analysed in the future studies to enhance performance models. The analysis investigates the performance and longevity of microsurfacing treatments categorized by pavement condition at the time of the microsurfacing treatment. Enhanced performance predictions for microsurfacing will improve life cycle cost analysis predictions and alternative treatment selection. Performance models for microsurfacing treatments are also valuable for understanding how to integrate preservation and maintenance into mechanistic-empirical performance prediction software.

Keywords: microsurfacing, pavement performance, pavement preservation, pavement service life.

1. INTRODUCTION TO MICROSURFACING

Microsurfacing is a mixture of polymer-modified emulsified asphalt, mineral aggregate, mineral filler, latex polymer, water and additives. The application of microsurfacing is expected to improve surface friction, seal surface cracking and filling wheel ruts up to 1 ¼ inches deep (South Dakota DOT 2010; Maher et al. 2005). This treatment is also effective at inhibiting ravelling and oxidation. Gransberg (2010) defines microsurfacing as "*a mixture of cationic polymer-modified asphalt emulsion, 100% crushed aggregate, water, and other additives properly proportioned and spread over a prepared surface*". Microsurfacing has three key traits that differentiate it from slurry seals: (1) the microsurfacing mixture always contains polymers, (2) chemical reactions cause rapid curing, and (3) the mixture can be placed in layers thicker than one stone deep (Gransberg 2010).

The rapid curing of microsurfacing allows traffic to be restored quickly, often within one hour after application (Lee and Shields 2010). Since microsurfacing does not enhance structural

capacity, it is not recommended for pavements exhibiting structural failures (South Dakota DOT 2010).

The service life of microsurfacing depends on environmental conditions, condition of the pavement and time of microsurfacing application (Hicks et al. 2000, Maher et al. 2001 and Ohio DOT 2001). Typically, microsurfacing service life is greater than seven years for high traffic and can be longer for low traffic volumes (Maher et al. 2005). An NCHRP Synthesis questionnaire of US state highway agencies (SHAs) revealed microsurfacing has an average life of six years within a range of one year to fifteen years (Gransberg 2010). Johnson (2000) also reported that the expected service life of microsurfacing is about seven or more years but performance life is dependent on the condition of the pavement before treatment application. The Ohio DOT estimates the service life of microsurfacing to range from five to eight years.

2. PAVEMENT PERFORMANCE DATA

Studies have been ongoing to better understand the performance of microsurfacing. Labi et al. (2007) determined the following influential factors on microsurfacing performance: pretreatment condition, freeze index, traffic, and pavement class; however, the pavement service lives were estimated using performance models developed by Indiana DOT, not actual historical data. Service lives are estimated based on the time elapsed by the pavement to revert to the pretreatment condition or a specific condition trigger (Labi et al. 2007). Ji et al. (2012) conducted structural evaluation of pavements by using the structural number (SN) to accurately evaluate the performance and life extension of microsurfacing. The study concluded that microsurfacing is not effective in terms of increasing pavement SN but does contribute to pavement life extension from one to one and a half years in terms of SN, two to three years in terms of roughness, eight years in terms of rutting and 4-15 years for pavement condition rating. Consistent and reliable methods for collecting data allows researchers to compile larger datasets to track performance.

3. PAPER OBJECTIVES AND METHODS

The objective of this paper is to analyze microsurfacing performance of projects placed from 2008 to 2014. For this study, microsurfacing performance was analyzed based on the pavement condition index (PCI). The PCI index ranges from 0 to 100 and is calculated from distress-specific indices. The general proportions and categories used to calculate the PCI for Iowa's pavement network are: 40% pavement cracking, 40% pavement roughness, and 20% pavement rutting (Bektas et al. 2014). The performance of microsurfacing treatments over time and the pre-construction condition of the pavement was considered. The findings of this research will improve our knowledge of microsurfacing performance and improve pavement candidate selection for microsurfacing.

4. MICROSURFACING PROJECTS INCLUDED IN THIS STUDY

Twenty-three microsurfacing projects with ninety-three sections were evaluated for this study. Additional projects have been constructed but do not currently have enough performance data to benefit the study. Figure 1 shows the number of sections (left axis), number of projects (right axis) and the construction year. In the graph, the bars represent the number of sections and the

number of projects is graphed using a line which references the right axis. Data is collected for each pavement section and analyzed. A single microsurfacing project may several sections and different sections may have different underlying conditions and pavement types. Table 1 shows the general pavement categories included in this study. Much of Iowa's state highway network has PCC somewhere in the underlying pavement layers and many of the composite pavements have two or more asphalt overlays.

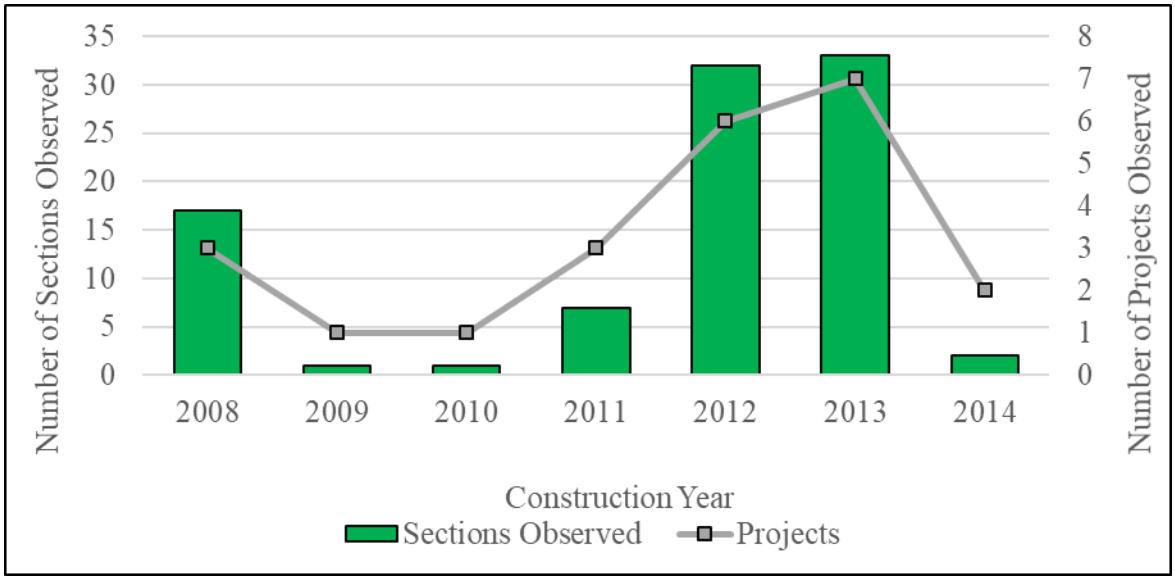

FIGURE 1 Number of Pavement Sections and Projects

TABLE 1 Pavement Types and Number of Sections Studied

Pavement Types	*Number of Sections Observed*
ACC	6
1 ACC Overlay ACC	8
2 ACC Overlays ACC	6
6 ACC Overlays PCC	4
5 ACC Overlays PCC	1
4 ACC Overlays PCC	4
3 ACC Overlays PCC	18
2 ACC Overlays PCC	25
1MSS, 1 ACC Overlay PCC	1
1 ACC Overlay PCC	12
PCC	9

5. MICROSURFACING DATA ANALYSIS

The Iowa DOT collects pavement performance data to track and improve pavement management. For this study, the pavement performance trends over time are plotted and box plots are used to provide summary statistics of the data. JMP, a statistical software, was used to

graph the information and calculate the box plot summary statistics. For each box plot, shown in Figure 2, the box represents the 3rd (upper) quartile and the 1st (lower) quartile, 75% and 25% of the data, respectively. The line through the middle of the box represents the median value. The 3rd quartile minus the 1st quartile represents the interquartile range (IQR). The whiskers extending from the box represent 1.5 x IQR (JMP 2017). The box plots with the graphs help to visualize trends of complex, variable data sets.

5.1 Initial pavement condition improvements from microsurfacing

Each pavement section treated with microsurfacing was categorized as "good", "fair" or "poor". The rating represents the pavement condition when microsurfacing was applied. A pavement with a PCI greater than 75 is categorized as good, a PCI in the range of 50 to 75 is fair and a PCI less than 50 is poor. Figure 3 displays the PCI improvement resulting from the microsurfacing treatment. For example, a "fair condition" pavement with PCI of 60 before microsurfacing and PCI of 70 one-year after microsurfacing would have a 10 PCI improvement. The analysis results are shown Figure 2. The pavements rated in good condition when the micro was applied already have high PCI values, so large increase is not observed. For pavements in fair and poor condition, the PCI improvement about 10 index points on average and 75% of microsurfacing treatments improved the pavements at least 4 index points. Pavements in poor condition showed an even higher average PCI increase of 12 points, for the first year. The initial increase in PCI shows that the improvement is dependent on the pre-existing condition of the roadway.

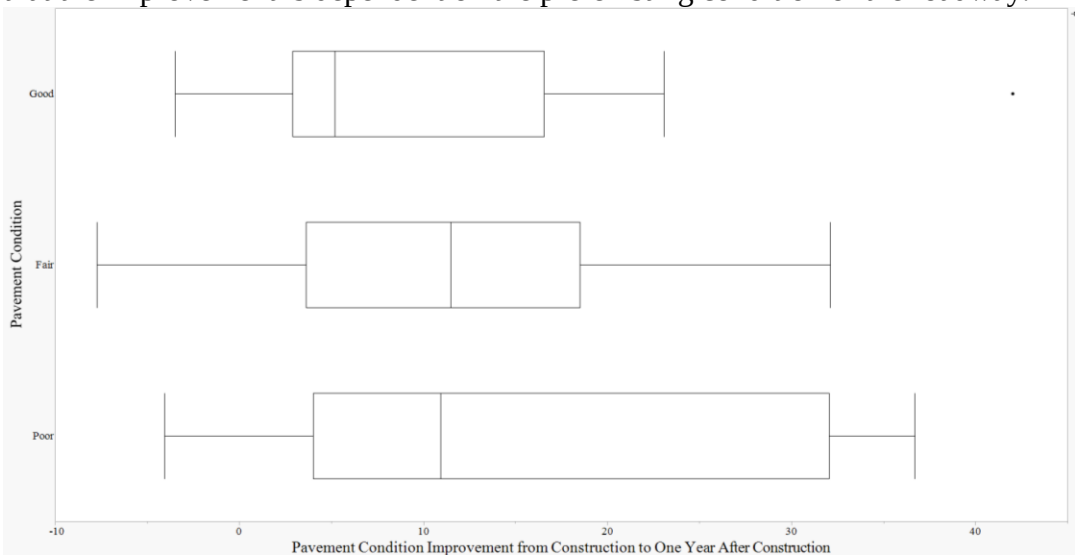

FIGURE 2 Pavement condition index improvement measured from pre-construction to one-year after microsurfacing construction

5.2 Improved rutting depth from microsurfacing treatment

Microsurfacing is often used to correct rutting in asphalt pavements. For this study, the rutting performance over time is presented in Figure 3. Microsurfacing age is shown on the x-axis where "0" represents the year microsurfacing was applied and a negative "micro age" represents the rutting data (in years) before microsurfacing was applied. Rut depth is shown for each year and is represented by a box plot. The one year before construction, -1, represents the best measure of improvement in rut depth. At year 1, the rut depth for more than 75% if sections

decreased to almost zero. There is a slight increase in the fourth year rutting data but remains below the pre-construction rut-depth. To adequately fill ruts of less than 12.5 mm, a full-width scratch coat to level the surface should be placed, followed by the final surface layer is recommended (ISSA 2010).

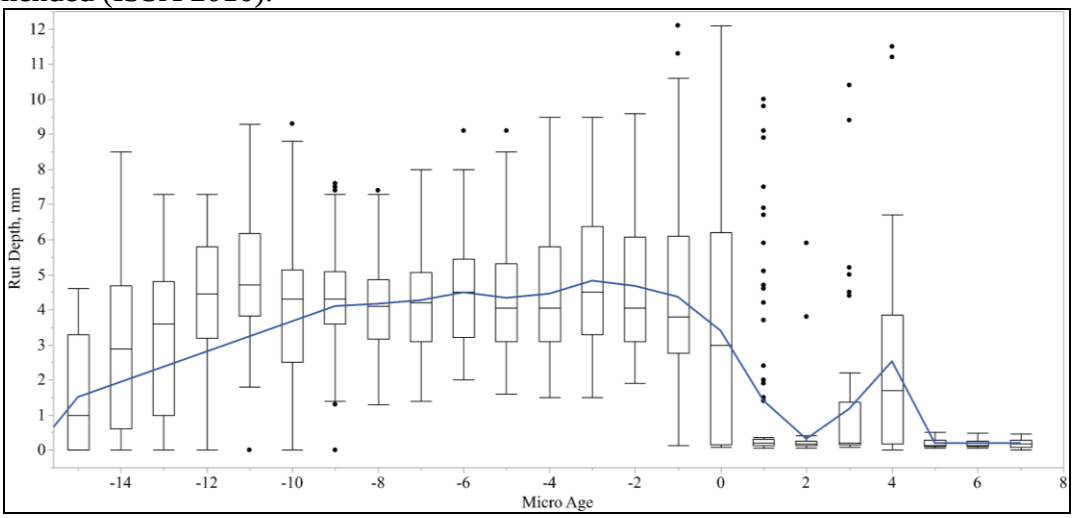

FIGURE 3 Rutting depth versus the age of the microsurfacing pavement (years) ***"0" represents the year of microsurfacing treatment.***

5.3 Microsurfacing Performance on Pavements in Good, Fair and Poor Condition

Figure 4 displays the PCI before and after the microsurfacing application. The blue solid line represents the mean and the red dashed line represents the number of observations in the dataset for that year. Figure 4 (a) displays pavements in good condition when microsurfacing was applied. The PCI trend shows good pavements remain in good condition after microsurfacing. Figure 4 (b) displays pavements in fair condition. Leading up to the microsurfacing treatment, the pavements show a steady deterioration and an approximate eight-point increase in PCI is observed followed by a deterioration curve similar to the pre-microsurfacing deterioration trend. The pavements are showing an approximate five-year average pavement life extension. The pavements in poor condition have a higher variability post micro application likely due to other rehabilitation activities performed after microsurfacing. The average trend also shows an approximate five-year life extension with differences in the data trends for good, fair and poor pre-treatment conditions.

6. CONCLUSIONS, RECOMMENDATIONS AND ACKNOWELDGEMENTS

The analysis of the microsurfacing data shows that microsurfacing provides life extension and improves rutting. Data trends indicate that pre-treatment condition influences performance. The estimated life extension average is five years based on PCI, an indexed combination of rutting, cracking and roughness. Pavements in good condition remained in good condition after treatment and fair and poor condition pavements service life extension with an increase in PCI.

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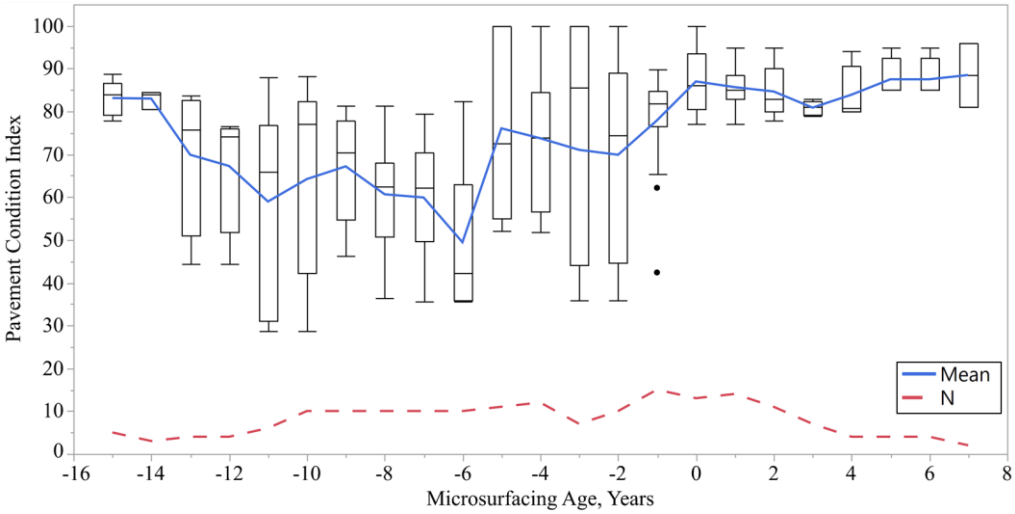
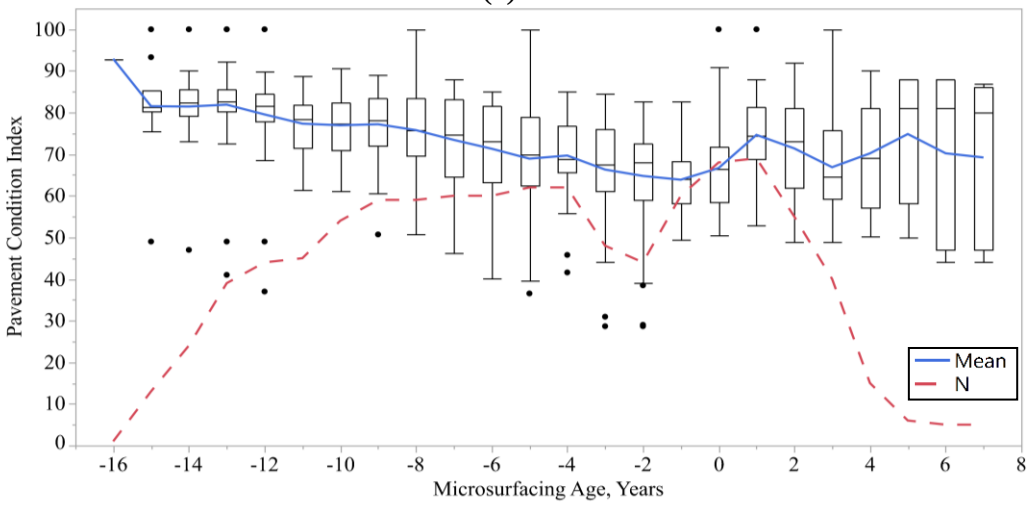


(a)



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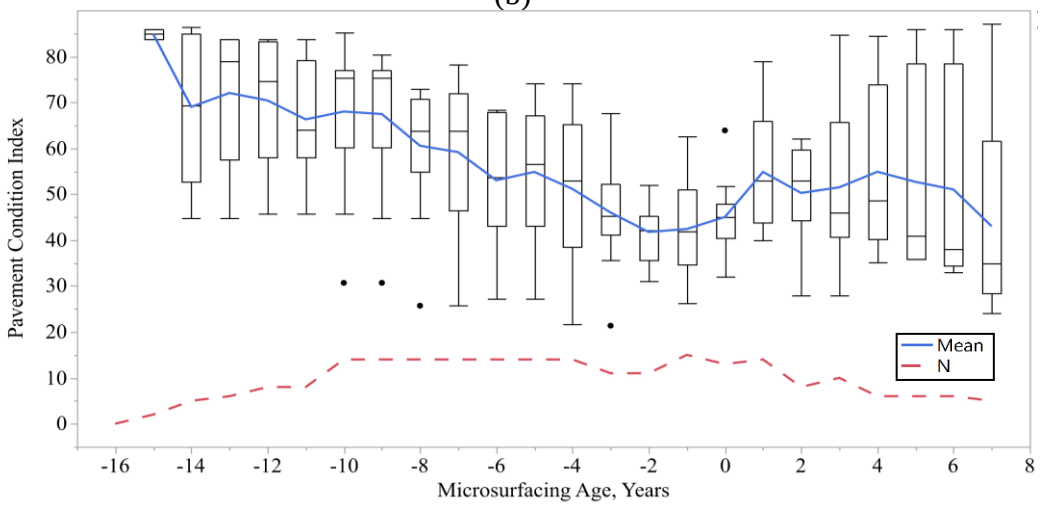

(c)

FIGURE 4 PCI performance with microsurfacing age for pavements in (a) good, (b) fair and (c) poor

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