Field Evaluation of Surface Characteristics of Microsurfacing Pavements

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Abstract

The Indiana Department of Transportation (INDOT) started to experiment with microsurfacing in pavement surface preservation. In order to provide first-hand, original data to better utilize microsurfacing in pavement surface preservation, a study was conducted to evaluate the surface characteristics of microsurfacing, in particular the surface friction properties. A total of six microsurfacing pavements were selected for field evaluation in this study. Field tests were conducted to evaluate the performance of microsurfacing, including pavement surface friction, surface depth and surface smoothness. Friction numbers were measured on freshly placed microsurfacing and as well as over time. Mean profile depth (MPD) was measured to assess the properties of surface macrotexture. The international roughness index (IRI) was measured to evaluate the surface smoothness. Data analysis was conducted to examine the effect of possible factors on the surface characteristics. Based on the results, the friction characteristics were identified and the typical MPD was determined. The improvement in surface smoothness from microsurfacing was assessed. It is believed that the original and reliable information presented herein can be utilized to better assess the performance of microsurfacing and perform engineering analysis.

Keywords

Microsurfacing, pavement friction, preservation, pavement roughness, rutting

1. Introduction

Microsurfacing is the application of a mixture of polymer modified asphalt emulsion, crushed and graded aggregate, mineral filler (commonly Portland cement to improve strength), water, and other additives, which have been properly proportioned and mixed, onto an existing HMA pavement. Microsurfacing is mainly utilized to correct rut and restore pavement friction. In many situations, however, microsurfacing can also be used to repair pavement surface damage such as weathering and raveling. While its mix is prepared and paved using a slurry seal machine, microsurfacing differs from slurry seal in that slurry seal uses a standard, conventional asphalt emulsion, but microsurfacing uses a polymer-modified asphalt emulsion. As a result, slurry seal requires more curing time (several hours) depending on the weather and pavement conditions for water evaporation and the asphalt emulsion to break and to be fully cured. Unlike a standard asphalt emulsion, a polymer-modified asphalt emulsion produces chemical action to drive water out, resulting in less curing time (usually less than one hour) and faster development of strength. Also, microsurfacing commonly uses higher quality aggregates.

On the one hand, microsurfacing uses nominal maximum aggregate size of 4.75-mm dense-graded fine aggregates, which allows an application as thin as 3/8 inch without compaction (Smith and Beatty, 1999). On the other hand, microsurfacing uses higher quality aggregates and polymer-modified asphalt emulsion and produces fast setting and greater strength, which allows thicker (up to 1 inch) application on high volume roadways to correct wheel path rutting that may exceeds ¾ inch and enhances long-term pavement surface friction performance. Particularly, the use of polymer modified asphalt emulsion can not only improve aggregate retention and enhance resistance to cracking and traffic wearing, but also reduce thermal susceptibility. The application of microsurfacing can be combined with other pavement preservation treatment such as chip seals to reduce aggregate loss, improve surface smoothness and provide desired pavement appearance. This paper presents the results of a study conducted to evaluate the field performance of microsurfacing, particularly the surface friction properties.

2. The Pilot Microsurfacing Projects

2.1 The Selected Test Sections

INDOT started to formally experiment with microsurfacing in 2007. Afterwards, several more microsurfacing projects have been completed for the purpose of field assessment. Presented in Table 1 is the information, including road, approximate length, traffic volume and construction completion date, on the six test sections that were selected for evaluating the surface characteristics of microsurfacing. All six test sections were located on two-lane highways. The test section on SR-3 was a resurfacing project running through the City of Rushville, consisting of 15 junctions with local town streets. The test section on SR-56 was 11.5 miles long, of which, one portion (about six miles long) was located outside of the City of Madison with an average annual daily traffic (AADT) of 2,267 and an average daily truck of 246, and the remaining portion was located inside the City of Madison with an AADT of 10,320 and an average daily truck traffic of 679. The greatest AADT of 15,596 was observed on SR-22 and the greatest truck traffic of 1,501 was observed on SR-3. The table shows that the six test sections covered a wide range of AADT on non-interstate highways.

Table 1: Microsurfacing Test Sections

Road	Length	AADT (2007)	Truck	Completion
SR-22	1.0 mi.	15,596	500	09/2007
SR-3	0.7 mi.	11,837	1,501	10/2007
SR-28	0.4 mi.	6,578	732	09/2007
SR-70	9.3 mi.	1,744	206	08/2008
SR-56	11.5 mi.	2,267/10,320	246/679	09/2008
SR-227	7.0 mi.	1,964	77	09/2009

2.2 Requirements for Microsurfacing Mixes

The polymer modified asphalt emulsion specified by INDOT is a quick-set, CSS-1H emulsion. The minimum polymer solids content is 3.0% based on the residual of the emulsion. Special additives are required to provide control of the quick-set properties. The coarse aggregates of Class B or higher is required for microsurfacing mixes. For rut filling, the required coarse aggregates include limestone, dolomite, crushed gravel, sandstone, steel furnace (SF) slag or Air Cooled Blast Furnace (ACBF) slag. The fine aggregates for microsurfacing are the same as those for HMA surface mixes, including limestone, dolomite, crushed gravel, sandstone, SF, ACBF or Polish resistant aggregate. When used for leveling application, the selection of fine aggregate type is based on the equivalent single axle load (ESAL) category. Summarized in Table 2 are the main quality requirements for both coarse and fine aggregates for microsurfacing. Table 3 shows the requirements for aggregate gradations used in microsurfacing, including leveling and rut filling applications. Portland cement of Type I is required to be used as the mineral filler. The detailed information on the quality requirements for microsurfacing materials can be found in the INDOT Standard Specifications (INDOT, 2010).

Table 2: Specifications for Microsurfacing Aggregates Properties

Requirements	Coarse Aggregate	Fine Aggregate
Aggregate Class	B or Higher	-
Los Angeles Abrasion, %, Max.	40	-
Freeze and Thaw Soundness, %, Max.	12	10
Sodium Sulfate Soundness, %, Max.	12	10
Brine Freeze and Thaw, %, Max.	30	12
Crushed Particles, %m Min.	70	-
Aggregate Angularity, %, Min.	95	45
Sand Equivalency, %, Min.	-	60

Table 3: Specifications for Microsurfacing Aggregate Gradation

Sieve Size (mm)	Leveling	Rut Filling
9.5	100	100
4.75	85-100	70-90
2.36	50-80	45-70
1.18	40-65	28-50
0.6	25-45	19-34
0.3	13-25	12-25
0.15	7-18	7-18
0.075	5-15	5-15

3. Surface Friction Characteristics

3.1 Friction on Freshly Placed Surface

A freshly placed microsurfacing can be opened to traffic after adequate cohesion has been developed to resist traffic abrasion. This usually occurs when the microsurfacing surface has turned black (Caltrans, 2003). Rolling with pneumatic rollers is not necessary but may be utilized to reduce aggregate loss. Presented in Figure 1 are the friction numbers measured on four of the six test sections right after opening to traffic. Two main observations can be made in Figure 1. First, it is apparent that the freshly placed microsurfacing pavements in the test sections produced sufficient surface friction. The lowest friction number was 28 on SR-22 westbound and the greatest friction number was 57 on SR-56 eastbound. Figure 2 shows a photo of a fresh microsurfacing pavement. While the surface was wet, the surface friction was sufficient to withstand traffic when opening to traffic. Second, the surface friction on the freshly place microsurfacing pavement varied significantly from test section to test section. This is probably due to the effect of curing process. The state of curing not only affects the development of mix strength, but also affects the surface properties. In reality, it has been pointed out that a microsurfacing pavement will not lose all water in the first hours after placement (Caltrans, 2003). It may take up to several weeks for the total water loss process to end, depending on the weather and existing pavement conditions. While the placement of the microsurfacing in one direction is always earlier than that in the other direction, the friction numbers on the freshly placed microsurfacing were very consistent in both directions in each test section. Therefore, a freshly placed microsurfacing pavement can not only provide sufficient surface friction, but also produce consistent surface properties and early opening to traffic. This confirms the benefits to use polymer in microsurfacing application.

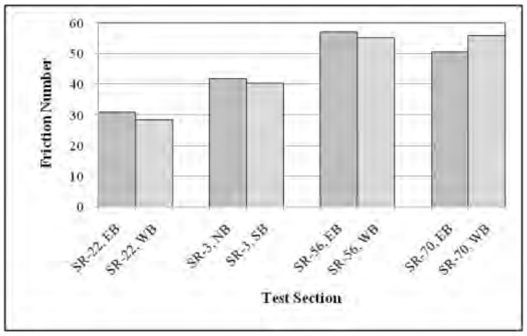


Figure 1: Friction Numbers on Freshly Placed Microsurfacing Pavements

Figure 2: Photo of a Fresh Microsurfacing Pavement

3.2 Friction Variation over Time

As curing proceeds, the strength of microsurfacing mix develops and the asphalt emulsion on the surface dries out. Presented in Figure 3 are the friction numbers measured in five of the six test sections over time. No friction variation was measured on SR-3. As mentioned earlier, this section consists of 15 junctions. It was very hard to conduct locked wheel friction testing without traffic control. In addition, some data such as the data on SR-22 after 12 months of service and on SR-56 after 18 months of service, is not available because the research team was unable to conduct testing due to other on-going major road works. As illustrated in Figure 3, the surface friction of microsurfscing pavement increased significantly in the first six months, and reached the maximum number approximately after 12 months of service. This indicates that the surface of a typical microsurfacing pavement may become stable and produce true friction numbers after 12 months of service.

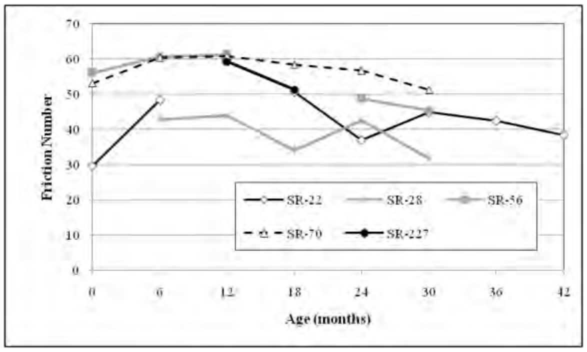


Figure 3: Friction Variations on Microsurfacing Pavements Over Time

Afterwards, the surface friction number decreased over time. Traffic volume had an impact on the variation of surface friction. The surface friction in the test sections with high traffic volumes, particularly truck traffic, decreased more than that with light traffic volume. Also, it appears that the surface friction in the microsurfacing pavements has always decreased after 12 months of service and tended to decrease faster over time. However, no friction number less than 30 occurred in all of the five test sections. A microsurfacing pavement commonly uses a 4.75-mm dense-graded fine aggregate mix. In reality, the aggregate gradation for the microsurfacing leveling mix is very similar to that for a conventional 4.75-mm HMA dense-graded fine aggregate mix. However, the use of polymer modified asphalt emulsion and special additives provides the microsurfacing mix enhanced properties.

4. Surface Macrotexture and Smoothness Characteristics

4.1 Surface Macrotexture

Illustrated in Figure 4 are the close-up views of the microsurfacing pavements in two test sections. The surface on SR-227 demonstrated aggregate particles protruding from the surface. The surface on SR-70 demonstrated angular aggregate particles. Both surfaces produced coarse textures. Texture testing was conducted to measure surface macrotexture profiles and associated mean profile depth (MPD) using a laser scanner (AMES Engineering, 2006 a). The reason for using such a device was that it would reduce testing time tremendously and minimizes the need for traffic control. Presented in Table 4 are the MPD values of surface macrotexture measured in the right wheel path in these five test sections. The greatest MPD was 0.951 mm that measured on SR-70. The lowest MPD was 0.366 mm that was witnessed on SR-22. In general, it looks that most measured MPD values were greater than 0.60 mm. When compared to the macrotexture depths of HMA pavements (Li et al. 2012), the microsurfacing pavements in these test sections produced surface properties much better than those on conventional 4.75-mm dense-graded HMA pavements and equivalent to those on 9.5-mm HMA pavements.

Table 4: Macrotexture Measurements

Test Section	Pavement Age	AADT/Trucks	MPD (mm)
SR-22	42 months	15,596/500	0.366-0.447
SR-28	30 months	6,578/732	0.779-0.934
SR-56	30 months	2,267 (10,320)/246 (679)	0.661-0.649
SR-70	30 months	1,744/206	0.665-0.951
SR-227	18 months	1,964/77	0.648-0.683

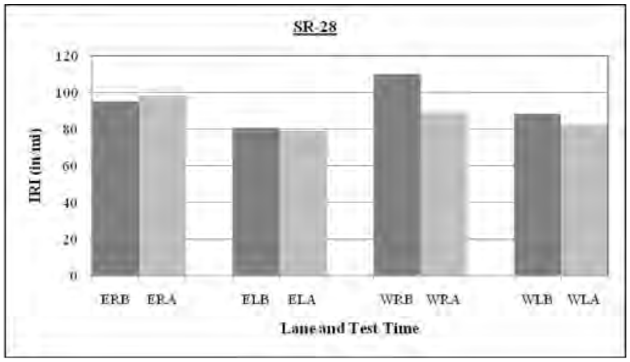
(a) SR-227 (b) SR-70

Figure 4: Close-Up Views of Microsurfacing Pavement Surfaces

A typical microsurfacing mix commonly uses dense-graded fine aggregates with a nominal maximum aggregate size of 4.75-mm. Particularly the aggregate gradation for the microsurfacing leveling is close to the aggregate gradation for a conventional 4.75-mm dense-graded fine aggregate mix. The reason that microsurfacing produces better surface macrotexture properties than a 4.75-mm HMA dense-graded pavement is not fully understood at this time. To the authors' knowledge, the strength mechanism for a microsurfacing mix is different from that for a conventional HMA mix. For microsurfacing mixes, the rheological properties of asphalt emulsion residue improve significantly due to the use of polymer and special additives. The microscopic honeycomb structure of flexible cement-polymer formed in a microsurfacing mix plays a critical role in early strength and rutting resistance (Takamura, 2001). Li et al. (2005) observed that HMA surfaces with rutting issues tended to experience low friction performance in the long term. Also, the polymers adhering to the aggregate surface may also have improved the properties of pavement surface texture.

4.2 Surface Smoothness

Field testing was conducted to measure surface longitudinal profiles (ASTM, 2018) using an inertial profiler system (AMES Engineering, 2006 b) and the international roughness index (IRI) (ASTM, 2003) was computed to assess the smoothness of the surface in each test sections. During testing, the longitudinal profiles were measured in both the right and left wheel paths in each direction. Figure 5 shows the IRI values measured before and after placing microsurfacing in three test sections located on SR-28, SR-70, and SR-227. In the figure, the three-letter symbols represent the direction of road, the wheel path, and the testing time. As an illustration, ERB denotes eastbound, right wheel path, and before microsurfacing. On the freshly placed microsurfacing, the surface smoothness varied between right and left wheel paths and between different directions. The IRI increased in two situations, one in the right wheel path on SR-28 eastbound and the other in the right wheel path on SR-227 northbound. However, the surface smoothness improved in most situations after placing microsurfacing. The greatest improvement occurred on SR-70 westbound with a decrease in IRI by 26%. Table 5 shows the IRI measurements made right after opening to traffic and in 2011. The test section on SR-28 experienced the greatest change in smoothness and the IRI increased by approximately 9 points each year. IRI increased by 1 to 6 points each year in other test sections. The IRI increased in proportion to traffic volume.



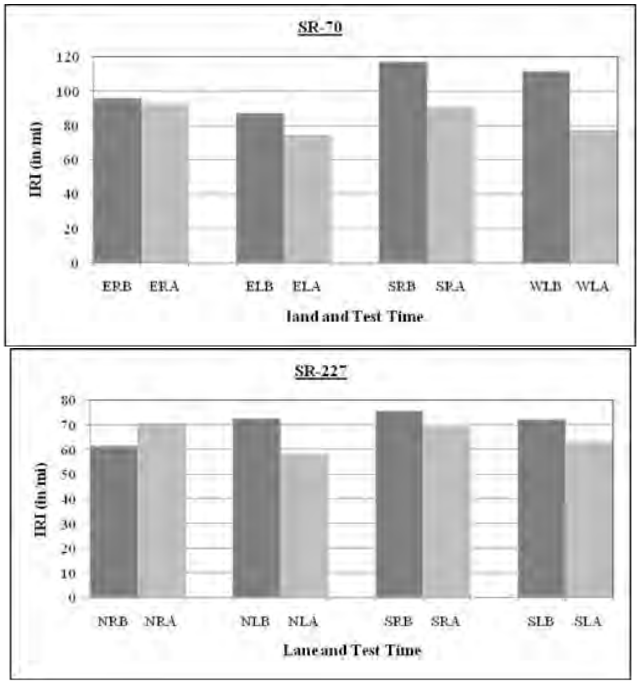


Figure 5: IRI Values in Three Test Sections

Table 5: IRI Variations over Time in Four Test Sections

Road	Direction	Months in Service	IRI on New Microsurfacing	IRI in 2011	IRI Decrease (%)
SR28	East	42	88.8	121.4	36.8
	West	42	85.8	116.2	35.4
SR56	East	30	60.4	73.8	22.2
	West	30	69.9	76.9	10.1
SR70	East	30	83.5	91.4	9.5
	West	30	84.0	86.6	3.1
SR227	North	18	64.1	71.2	11.0
	South	18	66.1	75.1	13.5

The above observations indicate that the smooth improvement from microsurfacing depended to some extent on the smoothness of existing pavement. The rougher the existing pavement surface the greater the smoothness improvement after placing microsurfacing. However, the effectiveness of microsurfacing in enhancing surface smoothness was limited, particularly when the smoothness of existing pavement was in good condition. This may be due to that microsurfacing in Indiana was commonly placed in two courses, including leveling and surface course. The thickness of microsurfacing was ultrathin, around 3/8” (9.5 mm). In addition, the application of microsurfacing was accomplished without compaction, which might also affect surface smoothness. It is also indicated that the surface smoothness in the left wheel path was always better than that in the right wheel path after applying microsurfacing.

5. Conclusions

Microsurfacing has been recognized as an effective treatment in pavement surface preservation. Based on the test data and analysis results from the study presented in this paper, the main conclusions can be reached as follows:

- Freshly placed microsurfacing could produce sufficient and consistent surface friction to withstand traffic and allow early opening to traffic. The friction numbers varied between 28 and 57 on freshly placed microsurfacing.
- The surface friction of microsurfscing pavement increased significantly in the first six months and reached the maximum number after 12 months of service. In other words, the microsurfacing pavements produced stable surface and true friction numbers after 12 months of service. Afterwards, the surface friction number decreased over time. However, no friction number less than 30 occurred in the test sections. Traffic volume had an impact on the variation of surface friction.
- The typical MPD was commonly greater than 0.60 mm. For microsurfacing mixes, the use of polymer and special additives may play a critical role in producing and maintaining good friction performance.
- The smooth improvement from microsurfacing depended to some extent on the smoothness of existing pavement. The rougher the existing pavement surface the greater the smoothness improvement after placing microsurfacing. However, the effectiveness of microsurfacing in enhancing surface smoothness was limited when the smoothness of existing pavement was in good situation. The surface smoothness in the left wheel path was always better than that in the right wheel path.

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