Nine Years of Microsurfacing in Oklahoma

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Microsurfacing was introduced in Oklahoma in 1983 through a FHWA demonstration project. Through 1991, more than 1900 lane-km (1,200 lane-mi) had been treated using the microsurfacing technique. Three microsurfacing projects were part of an in-depth study. These projects were monitored by obtaining rut measurements, surface friction tests, cracking measurements, deflection measurements, and condition surveys for at least 3 years after microsurfacing. Several other projects were examined to monitor special uses. These include microsurfacing over fabric, microsurfacing as an interlayer, using alternative aggregate, microsurfacing over portland cement concrete (PCC), and using synthetic latex. Microsurfacing has proven effective in filling ruts, reducing the amount of original rutting by 40 percent, and substantially increasing the friction characteristics of the pavement. It has also shown a moderate resistance to reflective cracking and does not increase the load-supporting ability of a pavement. Microsurfacing works well as a leveling course and as an interlayer but has not normally maintained a bond when placed over fabric. Two aggregate types have been used successfully and limited success has been achieved when placed on PCC pavement. The annual cost of microsurfacing is slightly more than an asphalt overlay, although the initial cost of microsurfacing is 55 percent of an overlay.

Asphalt pavements make up over 81 percent of the roadway in Oklahoma. Two distresses that commonly occur with asphalt pavements are rutting and surface condition distress. Rutting, combined with rainfall, can induce hydroplaning. Poor surface condition can reduce surface friction. These conditions can cause difficulties for the traveling public.

One technique to level a rutted pavement and provide surface friction is microsurfacing. Microsurfacing has also been used for filling cracks and sealing asphalt pavements. Microsurfacing, which is basically a latex-modified slurry seal, was developed in Germany in 1976 and was first used in the United States in 1980. Originally marketed under the trade name Ralumac, this process incorporates natural latex rubber with an asphalt emulsion. The mixture is combined with aggregate and other additives in a traveling pug mill similar to but larger than a regular slurry seal machine.

In 1983 as part of a FHWA demonstration project, the Oklahoma Department of Transportation (ODOT) contracted its first microsurfacing project. The project and data were presented earlier (*1*,*2*). Since then, the use of microsurfacing has increased each year.

BACKGROUND

Microsurfacing requires a siliceous aggregate with a high sand equivalency, a low abrasion loss, and a high percentage of acid-insoluble residue. Specifications for the microsurfacing mixture components allow 8 to 13 percent of latex-modified emulsion, 88 to 90 percent aggregate, 1.5 to 3 percent Type I portland cement, and 0 to 9 percent water and retardant.

The microsurfacing process involves the use of a self-propelled traveling pug mill in which the components of microsurfacing are mixed immediately before they are applied to a surface. The laydown machine is serviced by modified dump trucks that provide water, emulsion, and aggregate; the laydown machine carries the portland cement and retardant.

As with a slurry seal, no rolling of the microsurfacing is required for either rut filling or surfacing. Standard practice for ODOT consists of applying microsurfacing directly to the surface of a structurally sound asphalt concrete (AC) pavement in one or two passes with a laydown machine.

ODOT has been using microsurfacing since 1983. Through 1991, more than 1900 lane-km (1,200 lane-mi) had been treated using the microsurfacing technique on 75 projects. Three projects were established to provide an in-depth study of microsurfacing. Table 1 provides summary information of these projects, which were monitored by obtaining rut measurements, surface friction tests, cracking measurements, deflection measurements, and condition surveys for at least 3 years following microsurfacing.

The typical section for all three projects was very similar: a four-lane divided highway with 4.5 in. of AC on 8 to 12 in. of fine aggregate bituminous base. The Okfuskee project had an open-graded friction course placed on it in 1977, whereas the other two projects had no major maintenance activity performed before the microsurfacing.

Several other projects were examined to monitor special uses. These include microsurfacing over fabric, microsurfacing as an interlayer, using alternative aggregate, microsurfacing over portland cement concrete (PCC), and using synthetic latex.

The average annual precipitation in central Oklahoma is 81 cm (32 in.). The average annual snowfall is 23 cm (9 in.), with 20 wet freeze-thaw cycles per year. In January the mean low temperature is −3°C (27°F) and the mean high temperature is 8°C (47°F); in July the mean low temperature is 21°C (70°F) and the mean high temperature is 34°C (94°F).

PERFORMANCE MONITORING

The overall objective of the three in-depth studies was to measure quantitatively the durability of microsurfacing. Five surveys were performed for at least 3 years on each project: rutting, friction, cracking, deflection, and condition.

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TABLE 1 In-Depth Microsurfacing Studies

Highway	County	Const. Date	Microsurfacing Date	ADT[a]	ADTT[b]
US-64	Tulsa	1969	1983	40,000	14,000
I-40	Okfuskee	1965	1986	11,000	1,900
I-40	Canadian	1962	1987	17,000	4,100

[a] ADT - Average Daily Traffic
[b] ADTT - Average Daily Truck Traffic

Rut Survey

Rut depth measurements were made every 200 ft throughout the length of each project. Reduced rutting was maintained throughout 4 years of service (Figure 1). Rutting after 4 years on the Okfuskee and Canadian projects was approximately 60 percent of the original rut depth.

Friction Survey

Friction data were taken in accordance with AASHTO T242. All tests were run at 64 km/hr (40 mph) and were performed by the ODOT Traffic Engineering Division. The tests were performed in the travel (right-hand) lanes for the multilane roadways. ODOT uses a friction number of 35 as an indicator of acceptable surface condition.

In all cases, microsurfacing showed an improvement in friction values (Figure 2). The Tulsa project did show a reduction 3 years after treatment, but the value is still well above 35 after 9 years. The values for Okfuskee and Canadian after 4 years of service were still above the original level.

Crack Survey

Four 300-ft test sections were established on the Tulsa project and six 200-ft test sections were established on the Okfuskee and Canadian projects. The linear feet of cracking were measured before application and a percentage of the original measurement was determined in successive years.

The amount of cracking was improved significantly: a 50 percent reduction on the Okfuskee project, and an 83 percent reduction on the Tulsa project (Figure 3). Three of the six test sections on the Canadian project had 100 percent reflective cracking after 4 years; the other three sections ranged from 20 to 85 percent reflective cracking.

Deflection Survey

Benkelman beam surveys were conducted for three successive years on the Tulsa project and for four successive years on the Okfuskee and Canadian projects. Measurements were obtained every 200 ft over the entire extent of the project. Although microsurfacing improved the load-carrying ability for the Tulsa project, it did not improve it for the other two (Figure 4).

Deflection testing, as these tests indicate, is more of a reflection on the original pavement condition, because microsurfacing is not intended to significantly affect pavement strength. No explanation can be given for the significant improvement for Okfuskee in Year 2 and Canadian in Year 3.

Condition Surveys

Condition surveys as conducted by ODOT are semisubjective ratings of the overall condition of a roadway. Evaluation of

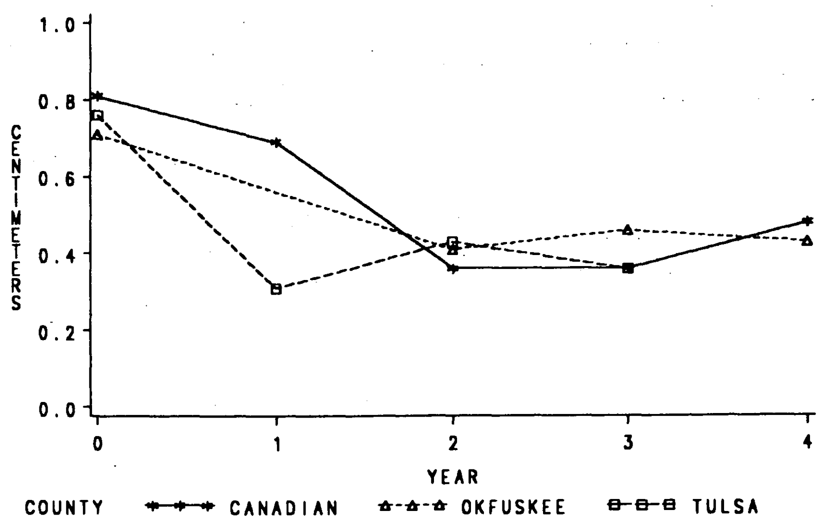

FIGURE 1 Average rutting on in-depth study sites (1 cm = 0.39 in.).

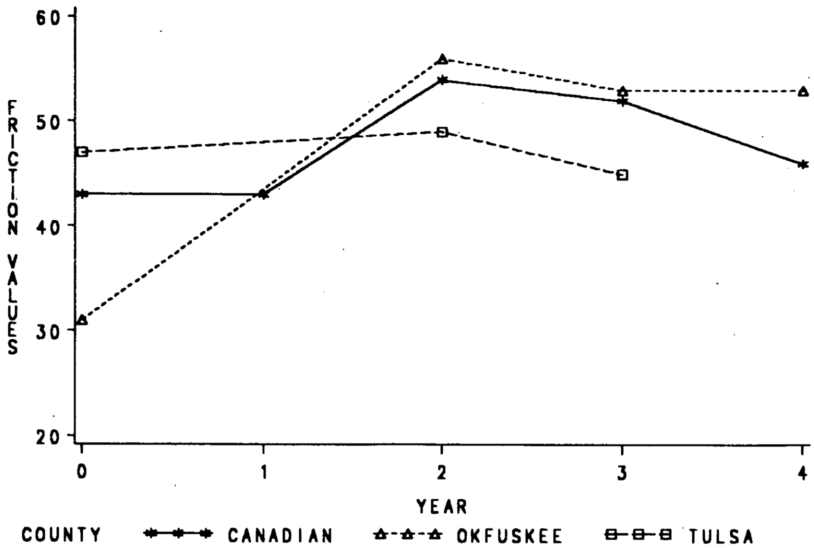

FIGURE 2 Average friction values on in-depth study sites.

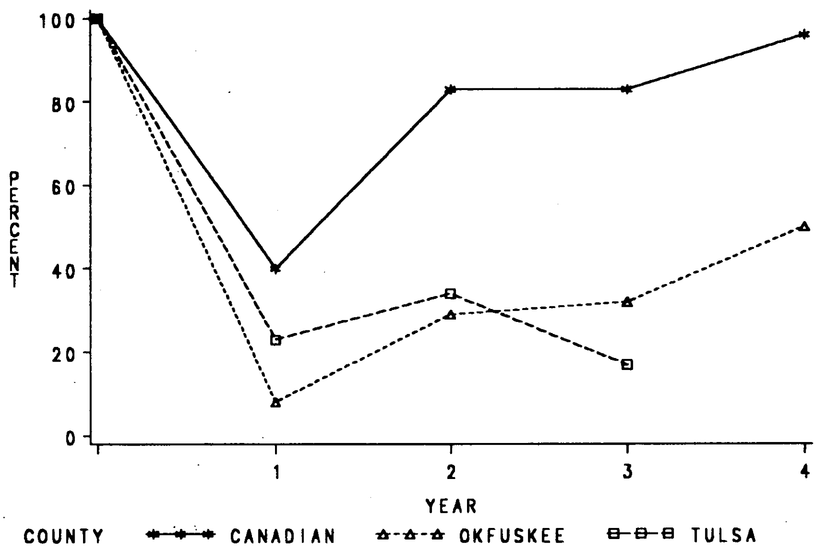

FIGURE 3 Percent cracking after microsurfacing on in-depth study sites.

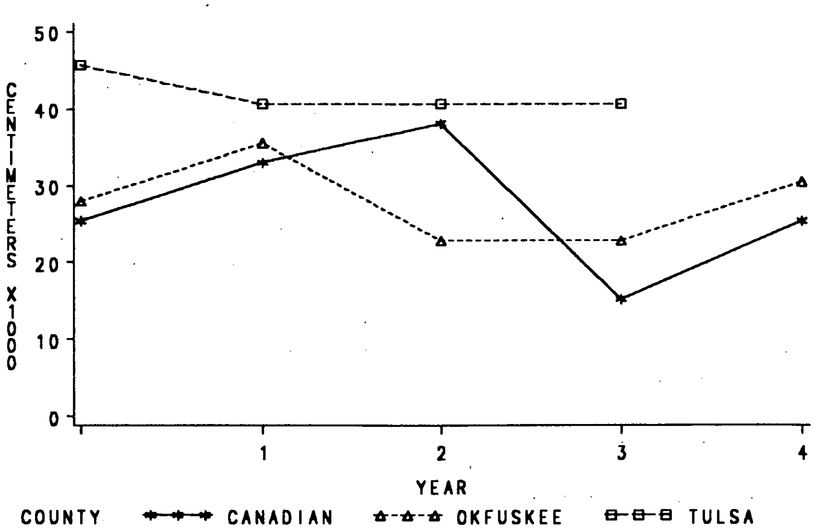

FIGURE 4 Average Benkelman beam deflection on in-depth study sites (1 cm = 0.39 in.).

a pavement section is performed for each 0.32 km (0.2 mi) covering such elements as pavement roughness, distortion, cracking, raveling, and base failure. The condition survey attempts to rate the condition of the entire pavement section and not just the surface course.

Condition surveys were conducted before microsurfacing and each year thereafter at approximately the same time of year. Figure 5 is a condition rating form used by ODOT. The general definitions and corresponding terms used for the condition surveys are given in the following ("few" or "slight" refers to less than 5 percent of the total area rated; "some," 5 to 15 percent; "considerable," 15 to 30 percent; and "extensive," more than 30 percent):

- Excellent (98 to 100 percent)
  - –No apparent major or minor defects
  - –No maintenance
- Superior (90 to 97 percent)
  - –No base failures or other major defects
  - –No structural maintenance
  - –Any one or all of the following characteristics present within 0.32 km: slight surface roughness, slight cracking, and very slightly impaired riding quality
- Good (80 to 90 percent)
  - –No base failures
  - –Any one or all of the following characteristics present within 0.32 km: some surface roughness, some cracking, slight raveling, and slight distortion
- Average (65 to 79 percent)
  - –Few localized base failures
  - –Considerable surface roughness
  - –Considerable cracking
  - –Some raveling, especially in outer wheel lanes and along edges
  - –Some distortion
- Poor (50 to 64 percent)
  - –Considerable base failures
  - –Extensive cracking
  - –Extensive raveling throughout surface width
  - –Considerable distortion
- Failure (less than 50 percent)
  - –Many extensive base failures
  - –Extensive distortion
  - –Extensive traffic hazards due to failures and distortion
  - –Ineffective routine and special maintenance repairs

The following terms are defined as they are used in the condition rating survey:

- Pavement structure—the traveled portion of the road, consisting of the subbase, base, and structure.
- Surface roughness—inequalities in the pavement surface that hurt riding quality.
- Cracks—approximately vertical cleavages due to natural causes or traffic action.
  - –A transverse crack follows an approximate course at right angles to the centerline.
  - –A longitudinal crack follows an approximate course parallel to the centerline.

The Okfuskee project had a condition rating of 57 before microsurfacing; it was due to raveling of the open-graded friction course being used as a surface course. Four years after microsurfacing, it had a condition rating of 76. The flaws noted in the last condition rating included popouts and patches.

The Canadian project had a condition rating of 85 before microsurfacing. After 4 years of service, it had a condition rating of 82. The flaws noted on the last rating for this project included depression cracking (evident from Figure 3) and patching.

USES OF MICROSURFACING

The primary use of microsurfacing is to fill ruts and reestablish the transverse profile of a roadway. Although most ruts were filled without any problems, ODOT had some problems in filling ruts of 3.8 cm (1.5 in.) or more in depth.

Early attempts to fill these deep ruts in one pass resulted in severe flushing of the emulsion. In these cases, the coarser aggregate had apparently settled to the bottom of the mix, leaving an oil-rich, flushed appearance. To avoid this problem, it is desirable to fill deep ruts in two passes; however, current laydown machines are set up to deliver slurry at the rate that the rut depth demands (filling the entire rut). To address this problem of filling deep ruts, ODOT has added a separate aggregate gradation to its specifications. This mix provides a dryer microsurfacing mix, which will help alleviate bleeding.

In some cases, the filling of deep ruts in one pass has been used with an overlay. To date, flushing during the filling of deep ruts has not affected the final surfacing lifts, nor has it compromised the friction values of the finished surfaces on projects where flushing was noted.

On the Tulsa project, microsurfacing was used to provide a "thick" surface course layer of 2.8 cm (1.1 in.) in one test section. The thick section rerutted worse than the normal microsurfacing and cracked slightly more than the normal section. Friction values for both sections were similar, and there was no appreciable difference in load-supporting ability. No other projects attempted to use a thick layer of microsurfacing as a surface course.

Microsurfacing has also been used to fill a variety of crack sizes and crack conditions. As with the filling of deep ruts, a specific aggregate mixture must be used, one that depends on the crack type.

On the Okfuskee project, microsurfacing was first used to fill alligator cracks. The mix used for this type of crack uses finer aggregate that helps penetrate the small surface cracks. On normal and depression cracking, the normal microsurfacing mix is used. Table 2 shows the three mix designs; there is no difference in the component percentage when any of these mix designs is used.

SPECIAL STUDIES

Besides a rut filler, crack sealer, and surface course, microsurfacing has been used in a variety of special studies. The studies allowed for an examination of microsurfacing in ways that are not considered standard practice.

Date: ____________________ | **CONDITION RATING FOR FLEXIBLE PAVEMENTS** | Project Number: ____________________

Location: ____________________ | Control Section: ____________________

Length: ____________________ | Surveyed By: ____________________

LEGEND FOR RATING CLASSES						
CONDITION RATING	CRACKING	DISTORTION	RAVELING	SURFACE ROUGHNESS	BASE FAILURE	TOTAL SURFACE AREA OF RATING INTERVAL
1. 100-98% = EXCEL. 2. 97-90% = SUPER. 3. 89-80% = GOOD 4. 79-65% = AVER. 5. 64-50% = POOR 6. 50%-LESS= FAIL	1-2-3-4	1-2-3-4	1-2-3-4	1-2-3-4	1-2-3-4	1 = LESS THAN 5% 2 = 5% TO 15% 3 = 15% TO 30% 4 = 30% OR MORE

		CRACKING						DISTORTION						RAVELING				SURFACE ROUGHNESS				BASE FAILURE			RUT DEPTH				
RATING INTERVAL (MI.)	CONDITION RATING (%)	Longitudinal	Transverse	Random	Block	Alligator	Cracking	Minor Bleeding	Inter. Bleeding	Major Bleeding	Shoving	Corrugating	Distortion	Minor	Intermediate	Major	Raveling	Smooth	Moderately Rough	Rough	Surface Rough	Moderate	Severe	Base Failure	0.1 to 0.5 inch	0.5 to 1.0 inch	1.0 or greater	PATCH FT^2	COMMENTS

FIGURE 5 Condition rating form.

TABLE 2 Acceptable Aggregate Mix Designs for Microsurfacing

Sieve Size	Type I (Alligator Cracking)	Type II (Normal)	Type III (Deep Ruts)
3/8"	100	99 - 100	98 - 100
No. 4	98 - 100	80 - 94	75 - 85
No. 10	68 - 86	40 - 60	45 - 55
No. 40	22 - 41	12 - 30	15 - 25
No. 80	10 - 25	8 - 20	8 - 15
No. 200	5 - 15	5 - 15	2 - 8

Fabrics

Six projects were examined in which microsurfacing was placed over fabric material on some portion of the project. The fabrics used on these projects were 95 g/m² (4 oz/yd²), nonwoven polypropylene. Of the six projects, only one project performed well. In most cases, there was some raveling within 2 months after the completion of the project.

Interlayer

Microsurfacing was used on one project to fill cracks and level the pavement before the application of a paving fabric and a 6-in. AC overlay. The microsurfacing was hand-poured to level wide depression cracks and squeegee'd by hand methods over thin alligator cracking.

There were no problems with the application of paving fabric over the microsurfacing leveling course. Six years after the completion of the treatment, the project is in excellent condition, with no reflective cracking.

Alternative Aggregate

Two projects were treated with an alternative aggregate source. The most common aggregate source used for microsurfacing in Oklahoma is in northeast Oklahoma; it is known as Miami chat (cherty limestone). The two projects, in western Oklahoma, used granite and dolomite for aggregate.

The first project failed because the aggregate was too dry. Further, the consistency of the aggregate mineralogy was affected by the presence of trap rock. The second project benefited from consistent mineralogy and the use of a "saturation hose" on the conveyor used to load dump trucks supplying the laydown machine. When the trucks reached the construction site from the stockpile, they were dripping water. Saturating the aggregate as it was loaded on the truck and ensuring that the quarry supplied consistent mineralogy as well as gradation enabled the second project to be successfully completed.

Friction resistance measurements made after the completion of this project showed values in the high 60s; measurements made after 3 years of service showed values in the low 60s. The values are substantially higher than the limit of 35 used by ODOT for acceptable friction resistance.

Since the completion of the second project, more projects in western Oklahoma have been treated using a mixture of 60 percent dolomite and 40 percent granite aggregate. The friction values are encouraging, but data are not yet available on the durability of the dolomite-granite aggregate mix.

On PCC

ODOT has limited experience with microsurfacing on PCC pavements. ODOT applied microsurfacing to PCC bridge decks on the Tulsa project but did not modify the surface before any treatment. After 4 years, there was significant raveling of the microsurfacing in the wheelpaths; however, the treated areas on the shoulders were not raveled.

On another project in central Oklahoma, one 18.3-m (60-ft) section of PCC pavement was treated. The average daily traffic on this project is 70,000 with 14 percent truck traffic. In this instance, the existing PCC pavement was treated with a tack coat of emulsion prior to microsurfacing. This patch showed limited raveling after 3 years of service.

Synthetic Latex

In 1987 a project in central Oklahoma was performed as an experimental evaluation of a new form of microsurfacing emulsion. The new emulsion used a synthetic latex and different emulsifier and set retardant than did the traditional microsurfacing mix.

The synthetic material provided for a quicker set than the traditional mix but did not accommodate lower temperature as well as the traditional mix. This project showed 100 percent reflective cracking after 3 years but improved the friction values from the high 20s before microsurfacing to the mid-50s after 3 years of service. Since this project, the ODOT specifications have been modified to address both material properties and construction procedures, allowing for the use of synthetic latex on all microsurfacing projects.

COST

Typical costs of microsurfacing on projects in Oklahoma from 1983 to 1991 ranged between $77 and $109/t. On all except a few Interstate projects, the only bid items have been emulsion and aggregate. Cost variations in these figures have been necessary to address traffic control and other non-bid item costs.

Average application rates have ranged from 8 to 14 kg/m² (21 to 37 lb/yd²) for rut filling, on the basis of a treatment 1.8 m (6 ft) wide for the outside lanes only. Average application rates for surface treatments have ranged from 8 to 12 kg/m² (23 to 32 lb/yd²), on the basis of a treatment 3.6 m (12 ft) wide.

Pederson compared the costs of microsurfacing with those of cold milling and a 3.75-cm (1.5-in.) asphalt overlay (*1*). Initial costs for the comparison show microsurfacing to be only 55 percent of the cost of the asphalt overlay. However, estimated lives for the two treatments are 5 years for microsurfacing and 10 years for the overlay. On the basis of annual costs and the estimated life cycles, the asphalt overlay becomes slightly more effective.

CONCLUSIONS

Microsurfacing

- Reduces the level of rutting and retards the rate of rutting, compared with pretreated rutting levels, after 4 years of service;
- Provides good friction characteristics of the pavement for up to 9 years of service;
- Has shown a moderate resistance to reflective cracking;
- Does not increase the load-supporting ability of a pavement;
- Can be used to fill ruts up to 3.8 cm (1.5 in.) deep;
- Works well for filling depression cracks and alligator cracks;
- Has generally not been successful when placed as a surface course over fabric;
- Works well as an interlayer;
- Has worked successfully with mine chat (cherty limestone) and a dolomite-granite aggregate mixture; and
- Has shown limited success on PCC.

Both natural and synthetic latex will work in the microsurfacing mixture. The annual cost of microsurfacing is slightly higher than an AC overlay, whereas the initial cost outlay of microsurfacing is approximately 55 percent of an overlay.

RECOMMENDATIONS

Microsurfacing is recommended for

- Continued use as a maintenance tool on both Interstate and state highway asphalt pavements,
- Filling ruts and reestablishing the transverse profile of an asphalt roadway,
- Restoring pavement friction characteristics, and
- Filling wide depression and alligator cracks.

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Publication of this paper sponsored by Committee on Pavement Maintenance.