MICROSURFACING WITH NATURAL LATEX MODIFIED ASPHALT EMULSION: A FIELD EVALUATION

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ABSTRACT

This paper presents an evaluation of the use of emulsified asphalt in a relatively new process called "Micro Surfacing". The process was developed in Germany and was first used in the United States in late 1980.

This micro surfacing process incorporates natural latex rubber with the asphalt emulsion. It is mixed with aggregate and other additives in a traveling pug mill similar to but larger than that of a regular slurry seal machine.

The test section that was selected for the micro surfacing application is a four-lane divided highway. It is three miles in length and in an urban area. The construction phase was completed in June, 1983.

The evaluation of data presented shows that the service life of the test section has been enhanced. It is recommended that the micro surfacing process be approved for routine use as a restoration item for flexible pavements to fill surface ruts and cracks, seal the surface, and/or restore skid resistance.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

MICRO SURFACING WITH NATURAL LATEX MODIFIED ASPHALT EMULSION: A FIELD EVALUATION

BACKGROUND

This is a report on the use of emulsified asphalt in a relatively new process called "Micro Surfacing". This process was developed in Germany in 1976 and was first used in the United States in 1980.

The original micro surfacing product, Ralumac, incorporates a natural latex with the asphalt emulsion. The micro surfacing consists of:

2.0 to 4.0% Latex Base Modifier(1) (incorporated in the emulsion)
1.5 to 3.0% Portland Cement (as mineral filler)
6.0 to 11.5% Residual Asphalt (the emulsion is 64% asphalt)(1)
82 to 90% Select Aggregate (sand equivalency $>$ 45)

Additionally, variable amounts of water and emulsion stabilizer are added during laydown operations. These two additives combined are roughly equivalent to 9 percent of the mix.

The latex modified asphalt emulsion is mixed with the aggregate and other additives in a traveling pug mill similar to but larger than a regular slurry seal machine. See Figure 1. The laydown machine uses two different sizes of slurry spreader box. A five and a half foot wide box is primarily used for rut filling and a thirteen foot wide adjustable box is used for surfacing. No roller

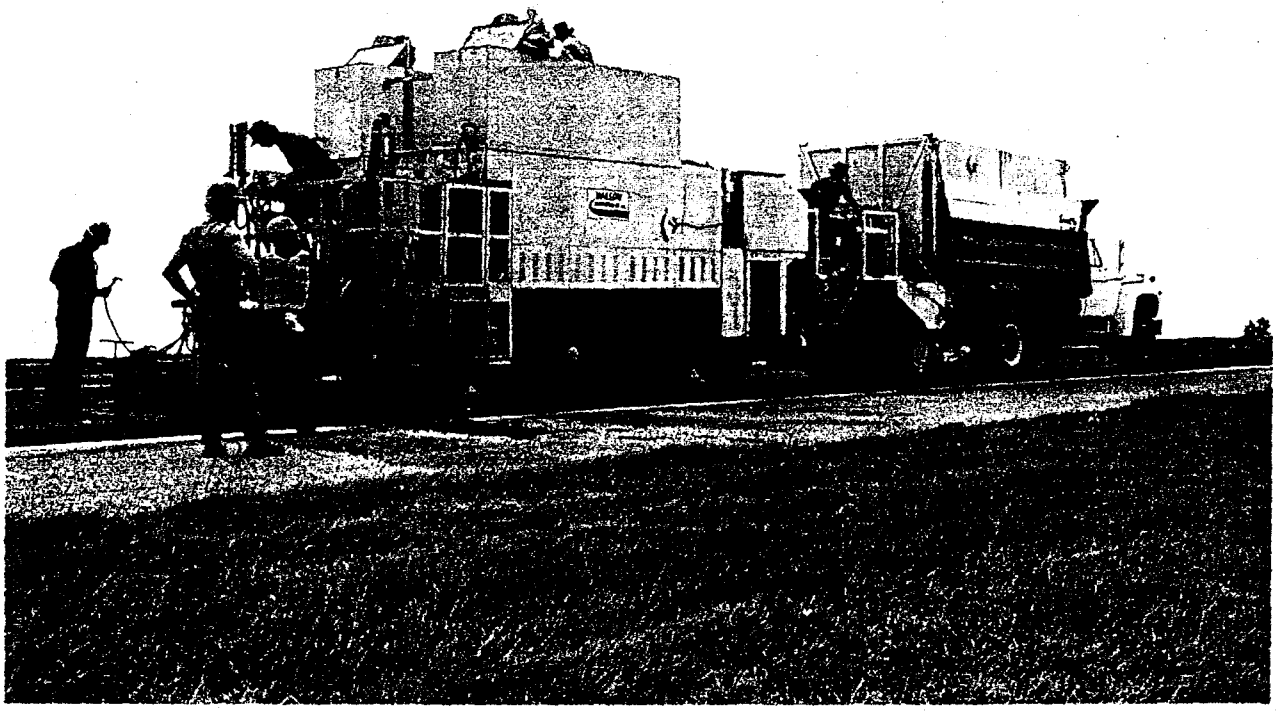

Figure 1. Micro Surfacing Laydown Machine with Truck.

compaction is required with either the rut filling or the surfacing.

The laydown machine is serviced by dump trucks that have been modified by the addition of two large tanks in their dump beds. These tanks carry emulsion or water. Each dump truck also carries a load of aggregate between the tanks. The laydown machine does have enough on board storage capacity to allow it to continue operating while servicing trucks are being switched. The only items which must be carried by the laydown machine are the Portland cement and the set retardant.

The basic crew for operating the micro surfacing machine consists of six people, four on the machine and two following behind. The two following behind carry mops or squeegees and do minor hand work as needed. On the machine, one person is required to add the Portland cement to a small hopper that meters the cement into the mix, a second person to hook up and monitor the service trucks, a third person to drive the laydown machine, and a forth person at the back of the machine controlling the actual laydown operation. The operator is able to adjust the amounts of aggregate, Portland cement, water, and set retardant going into the pug mill. Variations are made as dictated by weather and roadway conditions. On dry, warm days, the operator would add more water and set retardant. On cool, overcast or high humidity days, the operator would add less water and set retardant. The quality of a finished micro surfacing project depends greatly on the skill of the operator and his crew.

DEMONSTRATION PROJECT

In 1983, the Oklahoma Department of Transportation (ODOT), in cooperation with the Federal Highway Administration (FHWA), established a demonstration project to evaluate Ralumac micro surfacing. The evaluation project is located on US 64, a multi-lane divided highway in Sand Springs, Oklahoma. The project extent carries four distinct traffic volumes over its 3.35 mile length. The four sections as distinguished by Average Daily Traffic (ADT) are shown below:

	MILEAGE	ADT	COMMERCIAL	COMMERCIAL OVERLOADS
Section I	0.00 - 0.47	23,200	2,552	10%
Section II	0.47 - 1.64	18,400	2,706	10%
Section III	1.64 - 2.00	36,600	4,806	10%
Section IV	2.00 - 3.35	66,100	7,271	10%

The extent of US 64 covered in this study has the typical section shown in Figure 2.

Road Condition Before Construction

At the time of micro surfacing, US 64 was 14 years old. The roadway had received only routine maintenance during the 14 years since its original construction. Prior to micro surfacing, the roadway was badly cracked and had ruts up to 0.7 inches deep.

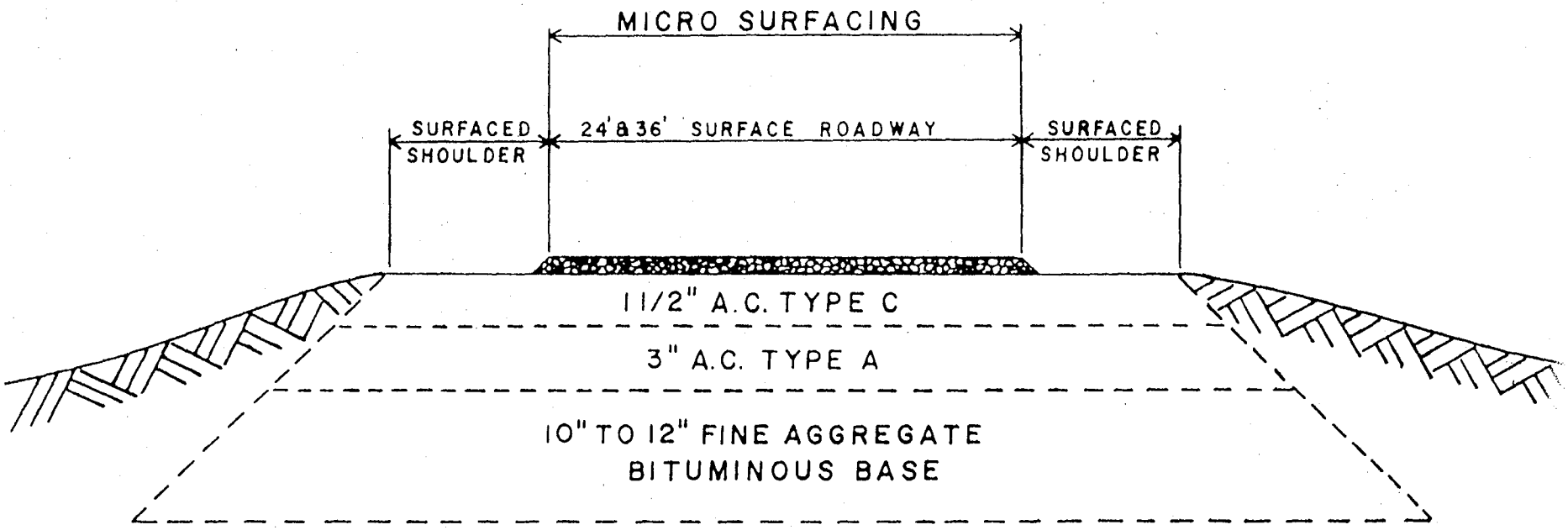

Figure 2. Half Typical Section of US 64.

The load supporting ability of the roadway as measured by Benkelman Beam deflections was adequate. The very nature of the problems on US 64 pointed to micro surfacing as a workable solution. Restoration of the profile of the roadway and sealing of the roadway surface on an otherwise sound road was needed. These needs could be met by micro surfacing.

Tests on the Project

The entire length of the project was tested for skid resistance, rut depths, load supporting ability, and ride quality. In addition to these tests, five 300 foot sections were evaluated for cracking. One of the sections in the eastbound lanes evaluated for cracking was treated with a 4 oz/yd^2 non-woven fabric.

A further test performed on this project was the comparison of the designed micro surfacing application with a thick application of micro surfacing and with an application of hot mix asphaltic concrete. Each of the three sections for this test consisted of 1,000 feet of roadway in the westbound lanes at the west end of the project. The nominal thickness of the designed micro surfacing treatment was 0.5 inches and that of the thick section of micro surfacing was 1.1 inches. The hot mix asphaltic concrete was laid 1.5 inches thick.

Construction

Work on micro surfacing US 64 began June 16, 1983 and required nine work days to complete. An additional work day was required for laying the test section of 1.5 inch thick hot mix asphaltic concrete. In the nine days of micro surfacing, a total of over 1,770 tons of material was laid. The job mix formula used on this project is found in Appendix A. The yields, as pounds of aggregate per square yard, are shown in Table 1.

TABLE 1

MICRO SURFACING APPLICATION RATES USED ON US 64

(Aggregate, lbs/yd^2)

Application	WESTBOUND		EASTBOUND	
	Outside Lane	Inside Lane	Outside Lane	Inside Lane
Rut Filling	29.44	none	35.00	none
Surfacing	15.90	21.20	15.90	21.40
Total	45.34	21.20	50.90	21.40

The 1,000 foot section used to test a thick application of micro surfacing required a total of 113.58 lbs/yd^2 of aggregate in three passes. The first pass was for rut filling, and two subsequent full width passes of the laydown machine were for surfacing.

There were no significant problems with the application of the micro surfacing.

Costs

The engineer's estimate for this project was 51,944 yd^2 at an application rate of 20 lb/yd^2 and 51,056 yd^2 at an application rate of 35 lb/yd^2. The contractor's bid price was \$1.12/yd^2 for the 20 lb/yd^2 application and \$1.40/yd^2 for the 35 lb/yd^2 application. The actual average final cost of the micro surfacing project was \$1.30/yd^2. All prices are in 1983 dollars.

Table 2 gives a brief cost comparison between micro surfacing and a treatment using cold milling and a 1½ inch A.C. overlay at 1987 prices. For the purpose of comparison, the application rates described in Table 1 have been used. The surface area of coverage is based on treating one mile of four lane divided highway with rut filling in the outside lanes only.

TABLE 2

Cost Comparison Scenario for Micro Surfacing vs 1 1/2" A.C.

Item	Item Cost[a]	Application[b]	Cost per (yd^2)	Coverage[c] (yd^2)		Extended Amount
Latex Modified Emulsion	$290.00/ton					
Aggregate[d]	$ 65.00/ton					
Micro Surfacing[e]	$ 94.25/ton	32.2 lb/yd^2	$1.52	12,907		$ 19,618.64
		15.9 lb/yd^2	$0.75	14,080		$ 10,560.00
		21.3 lb/yd^2	$1.00	14,080		$ 14,080.00
					Total	$ 44,258.64
				Annual Cost[f]		$ 8,851.73
1½" A.C. Type C	$ 28.00/ton	165.0 lb/yd^2	$2.31	28,160		$ 65,049.60
Tack	$ .60/gal	0.1 gal/yd^2	$0.06	28,160		$ 1,689.60
Cold Milling	$ .50/yd^2		$0.50	28,160		$ 14,080.00
					Total	$ 80,819.20
				Annual Cost[g]		$ 8,081.92

a. Item costs from 1987 Oklahoma DOT bid tabulations.

b. Micro surfacing application rates derived from Table 1.

c. Based on treating one mile of four lane divided highway with rut filling in the outside lanes only.

d. Type II aggregate. See Specification in Appendix B.

e. 13 percent modified emulsion and 87 percent aggregate.

f. Based on 5 year life expectancy.

g. Based on 10 year life expectancy.

Research Evaluation

The following figures and tables summarize data gathered to date on the US 64 evaluation project.

Wheel load data are presented in Figure 3. Wheel load data are adjusted for seasonal variations. The wheel load supporting ability of US 64 was improved by the application of the micro surfacing. This improvement in load supporting ability was still evident four years after micro surfacing was applied.

Figure 3 data relates to the overall project only and not to the three 1,000 foot test sections. In each of the three 1,000 foot test sections, Benkelman beam and rut depth measurements were taken every 200 feet. Benkelman beam data from the three 1,000 foot test sections indicated deflections less than 0.016 inches both before and after the surfaces were treated. There was no appreciable difference in the effect on load supporting ability between the 1½ inch A.C. section, the thick micro surfacing section, and the normal micro surfacing section.

Rut depth data are presented in Figure 4. Improvement of rut depths was shown in all four years after application of micro surfacing.

Figure 4 data relate to the overall project only and not to the three 1,000 foot test sections. Ruts in the three 1,000 foot test sections averaged 0.30 inches before any work was done. Four years later, in 1987, the 1½ inch A.C. section had rut depths averaging 0.4 inches, the thick micro surfacing section had rut depths averaging less than 0.3 inches, and the normal

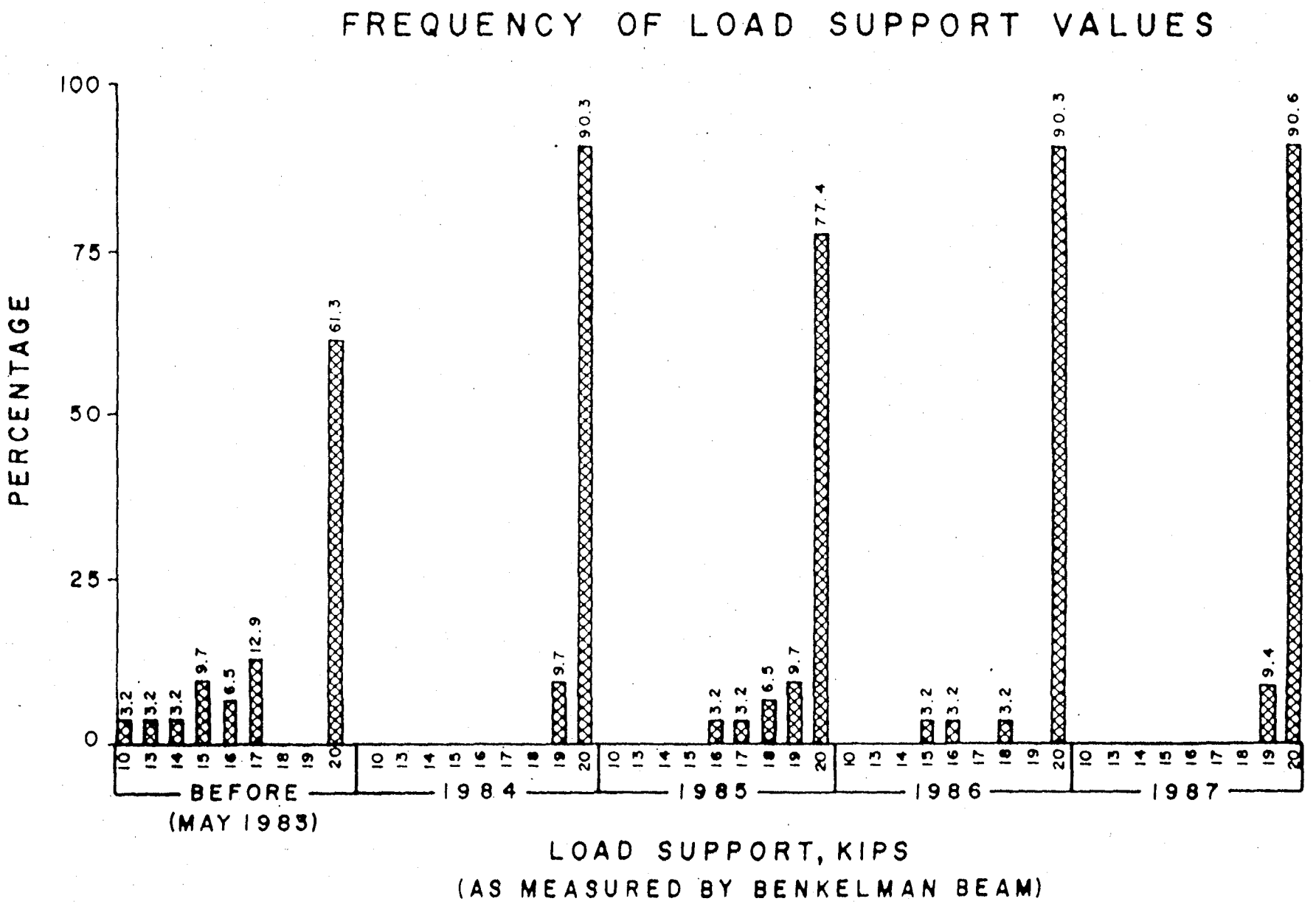

Figure 3. Wheel Load Supporting Ability

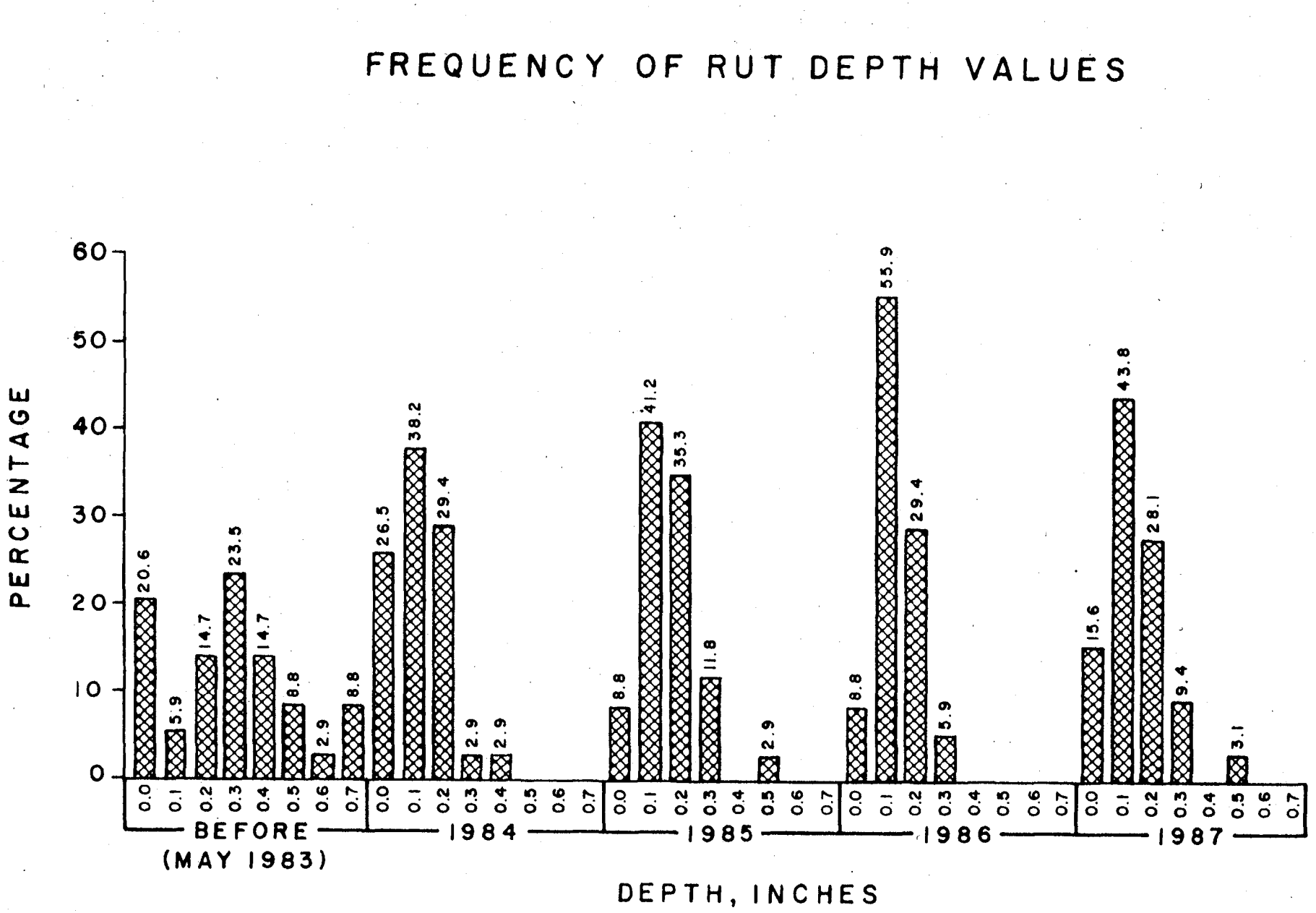

Figure 4. Rut Depths

micro surfacing section had rut depths averaging less than 0.2 inches.

Crack data are presented in Table 3. About one month before the application of micro surfacing, RS-2 asphalt was used to seal cracks within the extents of the micro surfacing project. The RS-2 had not fully cured prior to the application of micro surfacing, and later, as cracks reflected through, the RS-2 resealed some of them.(2) Thus, there were fewer open cracks after the third year than there were after the second year.

TABLE 3

CRACKING

300 Ft. Section	Before L.F.	Year 1 L.F.	Year 1 Pct	Year 2 L.F.	Year 2 Pct	Year 3 L.F.	Year 3 Pct
1	1735	364	21	649	38	526	30
2	1860	335	18	614	33	374	20
3	3170	761	23	983	31	568	18
4	3700	1008	27	1268	34	364	10
Fabric	1610	128	8	421	26	400	25

NOTE: L.F. = Linear Feet of cracking.

Pct = Each years cracking as a percent of the before data.

Table 3 data relate to crack sections located in the overall project only and not in the three 1,000 foot test sections. Although no quantitative measure of cracking was made in the three 1,000 foot test sections prior to micro surfacing, the general consistency of cracking throughout the project allows qualitative statements to be made. Four years after application of the three different treatments, the following qualitative statements can be made concerning cracking in the three test sections: Cracking in the normal micro surfacing section was less severe than the cracking in the thick micro surfacing section. Cracking in both micro surfacing sections was appreciably worse than the cracking in the 1½" A.C. section. Both micro surfacing sections exhibited transverse, longitudinal and random cracking. Additionally, the thick micro surfacing section exhibited block cracking. The 1½" A.C. section exhibited some transverse and longitudinal cracking.

~~Skid~~ data were obtained before, 2 years after, and 3 years after micro surfacing. These data indicate no significant change in the ~~skid~~ values before and after micro surfacing. The average ~~skid~~ number for the total project length before micro surfacing was 48. Two years after, the average ~~skid~~ number was 49. Three years after, the average ~~skid~~ number was 45. ~~Skid~~ data were not available for one and four years after micro surfacing.

The ride quality of the micro surfacing three years after application, as measured by a Mays Ride Meter trailer, was at an acceptable level. The average Present Serviceability Index was 3.2. The average inches of roughness per mile was 101.

Substitute "Surface friction" or "Friction" for "Skid"

Conclusions and Recommendations

In reviewing what information is available on the three 1,000 foot test sections, the following conclusions can be made after 4 years:

1. No benefit was realized from the application of the extra thick micro surfacing as opposed to the normal micro surfacing application.
2. There was no appreciable difference between the three test treatments in regard to their effect on the load supporting ability of the roadway.
3. The 1½" A.C. section performed better than either micro surfacing treatment in resisting cracking.
4. Both micro surfacing treatments performed better than the 1½" A.C. in resisting rerutting.

Results from the 300 foot fabric test section are inconclusive. ODOT currently has over 22 miles of micro surfacing on fabric that were laid in 1987. Observation of these sections will be required before any conclusive statement can be made about the use of fabric under micro surfacing.

Based on the field data obtained over the entire extent of the project, the following statements can be made pertaining to the condition of the roadway four years after treatment with micro surfacing.

1. The load supporting ability of the roadway, as measured by Benkelman beam, was generally improved over that measured prior to micro surfacing.

2. Rut depths were shallower overall that those measured prior to micro surfacing.
3. Based on data from the crack map sections, the quantity of cracking at four years was below 50 percent of the quantity of cracking measured prior to micro surfacing.

The results of the field tests conducted on US 64 show that micro surfacing enhanced the life expectancy of the roadway. It is recommended that micro surfacing be used as a means to restore flexible pavements that are rutting or cracking. Micro surfacing is not recommended for use on pavements that lack adequate load supporting ability.

UPDATED STATUS OF MICRO SURFACING

Upon completion of the evaluation of the demonstration project on US 64, ODOT was using micro surfacing routinely on state-aid projects. However, it remained an experimental feature on federal-aid projects, with evaluations continuing on several projects. Several hundred lane miles of the natural latex system were in place by the end of the 1987 construction season, including sections of heavily traveled interstate in the Oklahoma City area.

A second micro surfacing system, one using a synthetic latex, was placed under evaluation in the Spring of 1987. This system uses different emulsifying and set retarding agents than those used by the natural latex system.

At the end of the 1987 construction season, 21 lane miles of the synthetic latex system were under evaluation. One project on rural SH 77 used the synthetic latex system over its entire 10 mile extent. On one other project, the synthetic system and the natural system were placed end-to-end. This was a micro surfacing project on I-40 in Canadian County, Oklahoma, which incorporated a half mile long test section of the synthetic latex material within the extents of a 14 mile long project that used the natural latex micro surfacing. Evaluation of the micro surfacing products on these and other projects will continue at least through the early Summer of 1988.

This paper has dealt with one particular paving system using a latex modified asphalt emulsion. Latex and polymer modifiers are also in use with such paving processes as hot mix asphalt, cold mix asphalt recycling, and asphalt surface treatments. Modified asphalts are evolving and developing. It is certain that the years to come will bring several new paving materials composed of chemically modified asphalts.

REFERENCES

1. O'Brien, Louis and Ballou, William, "Ralumac Latex Modified Emulsion Mix Overlay", Sur-Tech, Inc., Harrisburg, Pennsylvania, November, 1982, pp. 4-5.

2. Pederson, C. M., "Micro Surfacing with Latex Modified Emulsion", Oklahoma Department of Transportation, Oklahoma City, Oklahoma, October, 1985, pp. 1-10.

APPENDIX A

Job Mix Formula

AGGREGATE

Sieve Size	Job Formula	Required by Specifications
3/8"	100	99-100
No. 4	87	86-94
No. 8	65	45-65
No. 16	44	25-46
No. 30	30	15-35
No. 50	18	10-25
No. 200	8	5-15
Sand equivalent	77	45 minimum
L.A. Abrasion	19.3	40 maximum

Percent Asphalt	Trial Mixes Specific Gravity	Hveem Stability
7.0	2.095	38
7.5	2.119	37
8.0	2.133	40

7.5 percent asphalt was recommended.

Note: Aggregate Type: mine chat.

APPENDIX B

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OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISIONS
FOR
MICRO SURFACING

These Special Provisions revise, amend, and where in conflict, supersede applicable Sections of the Standard Specifications for Highway Construction, Edition of 1976, and the Supplement thereto, Edition of 1984.

409.01. DESCRIPTION. (Amend to include the following). This work shall consist of the application of latex modified Micro Surfacing material to an existing surface. The modified Micro Surfacing shall be a mixture of emulsified asphalt, mineral aggregate, mineral filler, water, other additives, and a latex modifier properly proportioned, mixed and spread on the surface in accordance with these Specifications, and as directed by the Engineer.

409.02. MATERIALS. (Amend to include the following). (a) Emulsified Asphalt. The emulsified asphalt shall be CSS-1h (cationic). It shall show no separation after thorough mixing and shall conform to Subsection 708R.03.

(b) Mineral Aggregate. The mineral aggregate shall be chat aggregate commonly called "Joplin Chat" or Miami Chat", and shall conform to the following gradation requirements for the type specified.

	Percent Passing		
Sieve Size	Type I	Type II	Type III
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

(c) Mineral Filler. The mineral filler shall be a recognized brand of Portland Cement that is free from lumps. It may be accepted upon visual inspection.

(d) Water. The water shall be potable and shall be free of harmful soluble salts.

(e) Latex Modifier. A latex based modifier, "Dynatex Latex" as distributed by Guthrie Industries, Inc. or other approved equal, shall be milled into the asphalt emulsion. This additive shall allow the Micro Surfacing mixture to cure sufficiently so that normal traffic can be permitted within one hour's time, without damage to the surface.

(f) Other Additive. These additives are any other materials that are added to the Micro Surfacing mixture or any of the component materials to provide the specified properties. The emulsifier, "Peral No. 417" as manufactured by Raschig GMBH is the only other additive currently approved.

(g) Composition of Mixtures. The Engineer shall approve the design mix and all Micro Surfacing materials and methods prior to use and shall designate the proportions to be used within the following limits.

Residual Asphalt	6% to 11-1/2% by dry weight of aggregate.
Mineral Filler	1.5 to 3.0% by dry weight of aggregate
Latex Based Modifier	As required to provide the specified properties.
Water	As required to provide proper consistency.

The blended materials shall have a Hveem stability of 35 or more, when tested in accordance with OHDL-16.

Samples that are to be tested for stability shall be air dried for 2 to 3 days at room temperature. After air drying, the samples shall be placed in an oven at approximately 250° F. for a minimum of two hours. The samples shall then be molded in accordance with OHDL-8.

409.03. EQUIPMENT. (Amend to include the following). The material shall be mixed by a self propelled Micro Surfacing mixing machine which shall be a continuous flow mixing unit able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler and water to a revolving multi-blade mixer and discharge the thoroughly mixed product on a continuous flow basis. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler and water to maintain an adequate supply to the proportioning controls. The machine shall be equipped with self loading devices which provide for the loading of all materials while continuing to lay Micro Surfacing, thereby eliminating unnecessary construction joints.

Individual volume or weight controls for proportioning each material to be added to the mix shall be provided. Each material control device shall be calibrated and properly marked.

The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so the amount of aggregate used may be determined at any time.

The emulsion pump shall be the positive displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time.

409-5(c)
7-17-87

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box.

The mixing machine shall be equipped with an approved fines feeder that shall provide a uniform, positive, accurately metered, predetermined amount of the specified mineral filler at the same time and location that the aggregate is fed.

409.04. CONSTRUCTION METHODS. (Amend to include the following). (a) Weather Limitations. The material shall be spread only when the atmospheric temperature is at least forty (40°) degrees F. and rising and the weather is not foggy or rainy.

(b) Surface Preparation. The area to be sealed shall be thoroughly cleaned of all vegetation, loose aggregate and soil. Water used in pre-wetting the surface shall be applied at a rate to dampen the entire surface without any free flowing water ahead of the spreader box.

(c) Spreading. The Micro Surfacing mixture shall be spread uniformly by means of a mechanical type squeegee box, equipped with paddles to spread the materials uniformly throughout the box. Flexible seals shall be in contact with the road to prevent loss of mixture from the box. The rear flexible seal shall act as a strike off and shall be adjustable. The spreader shall be maintained to prevent the loss of the Micro Surfacing product in surfacing super-elevated curves. The mixture shall be spread to fill all cracks and minor surface irregularities and leave a uniform non-skid application of fine aggregate and asphalt on the surface.

The seam where two spreads join, shall be neat appearing and uniform. If in the opinion of the Engineer the seam is rough enough to cause a noticeable effect on steering of an automobile, the seam shall be removed and a new Micro Surfacing patch applied.

The self-loading devices shall be operated in such a manner as to eliminate unnecessary construction joints.

All excess material that overruns in gutters shall be removed or squeegeed back onto the surface.

All excess material shall be removed from ends of each job site immediately.

(d) Curing. Adequate means shall be provided to protect the Micro Surfacing from damage by traffic until the mixture has cured sufficiently so that it will not adhere to or be picked up by the tires of vehicles. Any damage done by traffic to the Micro Surfacing shall be repaired by the Contractor.

409.05. METHOD OF MEASUREMENT. (Amend to include the following). (a) Mineral Aggregate will be measured by the dry weight ton.

(b) Emulsified Asphalt will be measured by the gallon or ton.

409-5(d)
7-17-87

409.06. BASIS OF PAYMENT. (Amend to include the following). The accepted quantities measured as provided above, will be paid for at the contract unit price for:

(B)	EMULSIFIED ASPHALT	GAL. OR TON
(C)	TYPE I AGGREGATE	TON
(D)	TYPE II AGGREGATE	TON
(E)	TYPE III AGGREGATE	TON

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

APPENDIX C

TABLE C-1

WHEEL LOAD SUPPORTING ABILITY

(As measured by Benkelman Beam Deflections)

Deflection (Inches)	Approximate Load Support (Pounds)	Frequency of Test Values				
		Before	Years After 1	2	3	4
0.016 or less	20,000+	19	28	24	28	29
0.017	19,000		3	3		3
0.018	18,000			2	1	
0.019	17,000	4		1		
0.020	16,000	2		1	1	
0.021	15,000	3			1	
0.022	14,000	1				
0.023	13,000	1				
0.029	10,000	1				
Total Observations		31	31	31	31	32