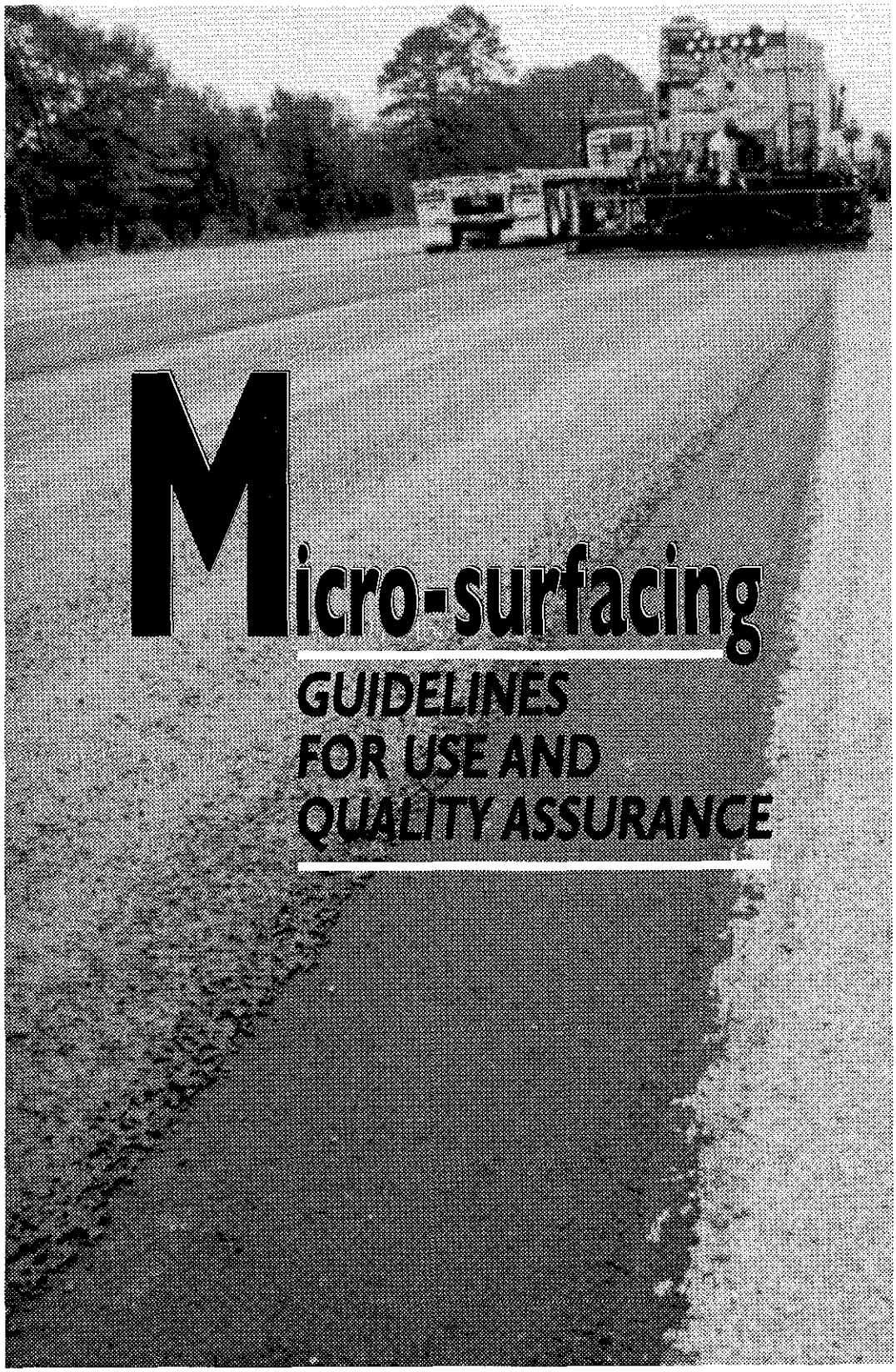
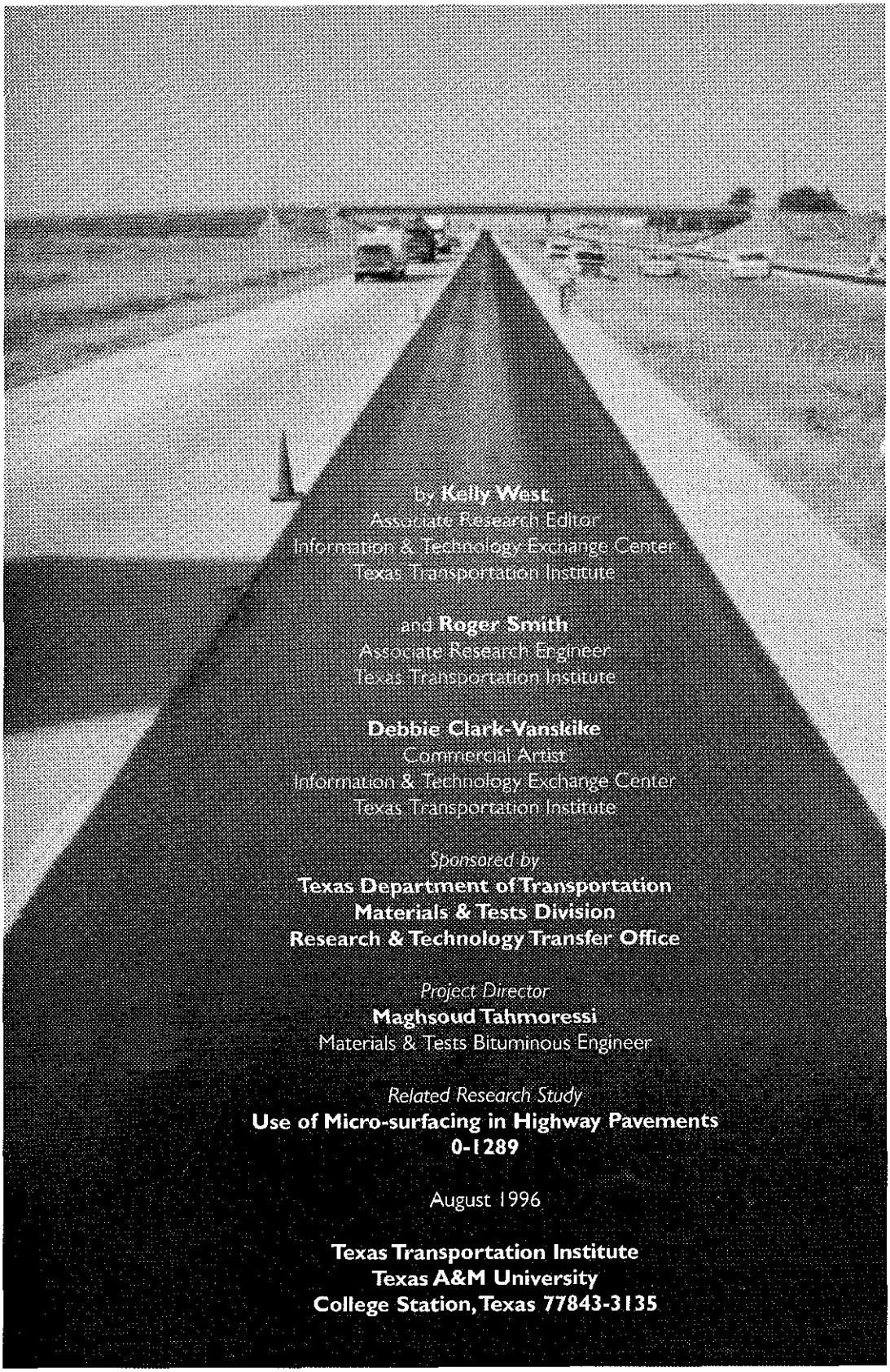


Micro-surfacing

GUIDELINES FOR USE AND QUALITY ASSURANCE



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These guidelines have been prepared for TxDOT personnel involved in micro-surfacing operations. This group includes inspectors, engineers, and crew members—all of whom are involved in different stages of the micro-surfacing operation. The guidelines are structured into two sections—use and quality assurance—covering the following areas:

- *general description of and background on use of micro-surfacing as a surface treatment and rut filler;*
- *field observation check list;*
- *quality assurance tests and checks for before, during, and after construction; and*
- *possible problems with micro-surfacing and corrections.*

Acknowledgments

Thanks go to Ballou Construction Co., Inc., and Viking Construction Co., Inc., for their assistance with obtaining photographs and source material and in the review process.

Table of Contents

Section 1

USAGE GUIDELINES FOR MICRO-SURFACING

Introduction

BACKGROUND

Since its 1980 introduction in Kansas, many other state and local agencies in the United States have used micro-surfacing on moderate to high volume roads. This includes Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, and Virginia. Thus far, use has shown micro-surfacing can be a successful rehabilitation and maintenance technique. However, it's important that managers and engineers fully understand limitations, performance variables, and materials/ mixture issues related to the strategy so that it is used only when appropriate. Until recently, information on research and actual application of micro-surfacing has been scattered and sometimes incomplete.

PURPOSE

This section of the document is prepared to provide guidance for appropriate selection and application of micro-surfacing in Texas. Analysis procedures are included which, if followed, should provide relatively good assurance that the micro-surfacing will give the desired service. This section includes:

- general information and guidance on the mixture and application;
- the use of the micro-surfacing as a surface treatment;
- the use of micro-surfacing as a maintenance treatment for rut filling; and
- time to opening information and guidelines.

GENERAL DESCRIPTIONS

THE MIXTURE

Micro-surfacing is a mixture of

- polymer-modified emulsified asphalt cement,
- well-graded crushed mineral aggregate,
- mineral filler (normally portland cement), and
- water, often with other additives (normally emulsifying agent).

The components of micro-surfacing are very similar to those used in hot mix asphalt concrete (a dense-graded aggregate with a polymer-modified binder). However, they are placed cold allowing for much thinner surfaces. The mixture design fixes the amount of mineral aggregate, polymer-modified emulsified asphalt cement, and mineral filler (cement).

The polymer-modified binder and 100% crushed, well-graded fine aggregate make the micro-surfacing more durable than most thin surfaces with conventional binders. Cement is normally used as the mineral filler and also acts as an accelerator for the breaking time of the emulsion. The additives are used to control break time when the material is placed during hot seasons.

The mixture is designed to handle traffic within about one hour after placement for normal environmental conditions. Service life of micro-surfacing applied to pavements in the appropriate condition appears to be five to seven years for relatively high traffic roads and may be considerably longer for those with low to moderate traffic.

APPLICATION

The aggregate, mineral filler, polymer-modified emulsified asphalt cement and water are mixed in a truck-mounted traveling plant. The mixture is deposited into a spreader box mounted behind the truck which spreads it across the pavement surface. No compaction is applied. The equipment operator changes the amount of water to control the consistency of the mixture and the amount of additive to control the time at which the emulsion breaks and the time traffic can be applied to the finished surface. Changes in temperature, humidity, and texture of the existing surface generally lead to a change in the amount of additive required.

USAGE

Micro-surfacing is generally used as a maintenance or surface treatment for an existing pavement with an asphalt concrete surface. As a surface treatment, it provides a skid-resistant surface. As a maintenance treatment, micro-surfacing is also used to fill ruts. Micro-surfacing has been used on portland cement concrete surfaced pavements and bridge decks; in these cases it is used primarily to develop surface friction.

HISTORY[1]

Micro-surfacing was first developed in Europe, where it is generically known as micro asphalt concrete. In the mid-1970s Screg Route, a French company, designed its Seal-Gum, a micro asphalt concrete that was subsequently improved by the German firm Raschig. Raschig marketed its product in the United States under the trade name "Ralumac" during the early 1980s. Later, the Spanish firm Elsamex developed and marketed its micro asphalt concrete in the U.S. under the name Macroseal. Today several other proprietary and generic systems are available in the U.S.

HOW IT WORKS

Preserving structural capacity

The application of micro-surfacing *does not* increase the structural capacity of the pavement; however, it does help *preserve* the structural capacity, primarily by reducing the environmental damage that would otherwise develop in the original asphalt concrete pavement from the surface down. Increased moisture levels will reduce stiffness of most pavement layer materials. Reduction of moisture infiltration reduces this loss of strength and may allow some strength to be regained during hot, dry periods. This preserves the structural capacity of the existing pavement so that it can continue to effectively support traffic loads.

The structural capacity and adequacy of the pavement should be determined prior to selecting micro-surfacing as a treatment.

The structural capacity and adequacy of the pavement should be determined prior to selecting micro-surfacing as a treatment. This can be accomplished by design and analysis procedures available in TxDOT. It is suggested that a seven- to ten-year period be used in the analysis to ensure that the pavement will be structurally adequate through the expected life of the micro-surfacing treatment.

Decreasing pavement permeability

Water entering the asphalt concrete layers carries dissolved oxygen and trace chemicals which contribute to the oxidative hardening of the asphalt concrete surface. Oxidation leads to weathering, raveling, and surface cracking of the pavement surface. By placing a protective layer on the existing surface, the permeability of the surface is reduced. This means that weathering, raveling, and age accelerated surface cracking is less likely. It may also reduce the rate at which other moisture-induced damage such as stripping develops.

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[1]This section is taken from Publication No. FHWA-SA-94-051 "State of the Practice Design, Construction, and Performance of Micro-surfacing," by Hassan Raza, P.E., Federal Highway Administration, June 1994.

Providing surface friction

Micro-surfacing provides good surface friction when skid-resistant and polish-resistant aggregates are used in the mixture.

Correcting moderate flushing and bleeding

Micro-surfacing has been placed on pavements with moderate flushing and bleeding. Some success has been achieved; however, generally two layers are needed to substantially reduce the probability of the underlying excess asphalt from causing flushing in the micro-surfacing. Adequate experience is not available at this time to determine how long micro-surfacing will retard flushing.

SELECTION GUIDELINES

MICRO-SURFACING AS A SURFACE TREATMENT

Surface treatments are used as preventive and corrective maintenance treatments. Micro-surfacing applied to existing bituminous surfaces reduces deterioration caused by weathering, raveling, and oxidation of the pavement surface. It also provides a wearing surface with good surface friction, if the appropriate aggregate is used. As a surface treatment, the thickness of the micro-surfacing layer is approximately equal to the maximum size of aggregate used in the mix.

Rule of Thumb

Use micro-surfacing in place of conventional seal coats:

- at approaches to major intersections,
- on urban arterials with an asphalt surface,
- on interstate pavements with an asphalt surface,
- on other high traffic asphalt surface pavements, or
- when traffic volume is too high or where vehicles perform too many turning and stopping movements for a conventional seal coat.

Some of the corrective capabilities and benefits of micro-surfacing include:

- providing or restoring skid resistance,
- reducing entry of air and water into the existing asphalt concrete,
- attaining a uniform appearance,
- sealing small, "nonworking" cracks,
- minimizing loss of curb height,
- requiring no manhole and other structure adjustments,
- reducing rock loss and windshield breakage,
- increasing visibility of pavement surface at night, and
- possibly preserving the pavement's structural strength.

Layer thickness guidelines

Micro-surfacing applied as a surface treatment will vary in thickness and weight of micro-surfacing per unit area when the surface texture of the pavement changes. The basic goal is to place the material with a thickness that is slightly greater than the maximum size of the aggregate in the mixture.

Material thickness should be slightly greater than the maximum size of mixture aggregate:

Surface	Material Needed
badly raveled; or coarse and open	more
nearly smooth or almost flushed	less

Typical application

rates are 98-146 Kg/m² (20-30 lbs/sq yd). The exact rate will depend on the texture of the existing surface. When the existing surface is badly raveled or otherwise coarse and open, more material is needed to fill the surface voids. When the surface is nearly smooth or almost flushed, less material will be needed. If too little micro-surfacing is placed on an open surface, individual pieces of aggregate will be caught by the spreader box and pulled along the road surface creating excessive drag marks. This should be expected between wheel paths on "scratch coats," but it is generally considered unacceptable on the final surface. When the surface texture of the existing pavement is nonuniform, the surface of the micro-surfacing will also be nonuniform. So a "scratch coat" will be needed prior to application of the final surface to create a uniform surface.

When not to use micro-surfacing as a surface treatment

Micro-surfacing, like other surface treatments, is not a cure-all treatment. It will not seal cracks nor will it be able to prevent cracks from reappearing. Most larger-than-hair-line cracks will reflect through the micro-surfacing relatively quickly. Micro-surfacing adds no structural strength to a pavement and does not correct excessive longitudinal roughness problems.

If cracking is the major problem on the pavement, then micro-surfacing should not be used. Most cases where micro-surfacing is lost after application in the wheel path appear to be related to placing micro-surfacing over pavement that is experiencing fatigue or alligator cracking. Sealing this type of crack before application of micro-surfacing will do little to prevent the cracking from damaging the micro-surfacing. Micro-surfacing will provide the longest service and best life extension when applied before significant surface observable distress becomes obvious, especially cracking.

General Pavement Evaluation Guidelines

- The pavement should be structurally sound and suitable for future traffic over the expected life of the micro-surfacing.
- Transverse cracks should be sealed, and localized areas of fatigue (alligator) cracks should be repaired prior to placing the micro-surfacing.
- Micro-surfacing can be used on high volume rural highways, urban arterials, and intersections where surface seals are needed but not normally considered feasible.

MICRO-SURFACING AS A RUT FILLER

Micro-surfacing has been successfully used to fill ruts up to 50 mm (2 in) deep. Rut filling will only be successful if the rut is caused by mechanical compaction of the pavement structure. Filling ruts corrects the surface profile, but a rut

A curing period of one day to a week is generally needed between successive layers of micro-surfacing

Rule of Thumb

Use micro-surfacing as a rut filler when:

- The pavement is structurally sound for the future traffic over the expected life of the micro-surfacing.
- The ruts were caused by mechanical compaction of the pavement structure.
- Ruts are flat, not sharp or showing dual wheel marks.
- Ruts are indentations only, not an indentation between upward heaves.
- Ruts do not contain fatigue (alligator) cracking.

is often a symptom of an underlying pavement problem which micro-surfacing cannot repair.

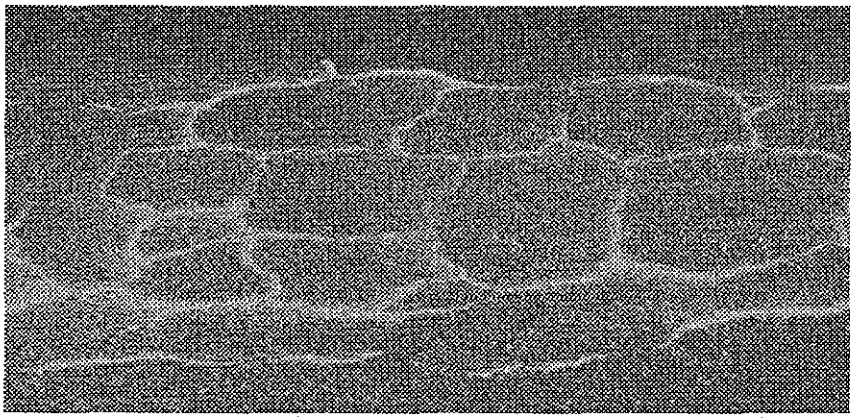
If the pavement surface has been in service for fifteen years and has developed relatively flat rutting 12 to 18 mm (1/2 to 3/4 in) deep, filling the rut with micro-surfacing may provide the desired transverse profile for a reasonable period.

Layer thickness guidelines

Because micro-surfacing is placed using a cold process, the material is initially relatively fluid. This means it can be placed in thin layers and can be used to level longitudinal rutting depressions. The polymer-modified asphalt cement binder and 100% crushed, dense-graded aggregate generate a mixture stable enough to withstand traffic loads more than one maximum-size aggregate thickness. The maximum micro-surfacing thickness applied in a single lift should not exceed 25 mm (1 in). Each individual rut fill, utilizing a rut filling spreader box, should be slightly crowned to compensate for traffic compaction.

Rut depth	Action
greater than 12 mm (1/2 in)	Use a special rut filling spreader box (rut box) to fill the ruts before the final surface is placed.
less than 12 mm (1/2 in)	Use full-width scratch coat pass to level the surface before the final surface is placed.
in excess of 25 mm (1 in)	Use multiple placements of micro-surfacing using the rut box to fill the rut.

When used to fill ruts greater than about 12 mm (1/2 in) deep, a special spreader box (rut box) is used with the truck-mounted mixer. A separate pass of the equipment is made to fill the rut in each wheel path. Generally, a final pass is made with a conventional spreader box to cover the entire lane. Ruts in

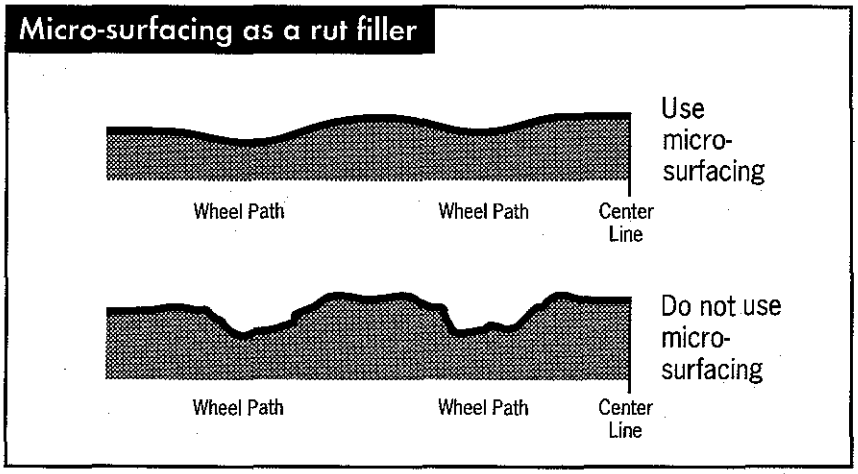


Extensive alligator cracking cannot be repaired with micro-surfacing.

excess of 25 mm (1 in) deep generally require multiple passes with the special rut filling spreader box to restore the original cross section. A curing period of one day to a week is generally needed between successive layers of micro-surfacing. If the first layer is not adequately cured, the construction equipment will tear it from the original surface during application of the next or adjacent layer.

When not to use micro-surfacing as a rut filler

If the pavement is structurally inadequate, the micro-surfacing will not provide adequate structural improvement and will not prevent further deterioration. If the ruts have extensive alligator cracking and shear failure, or are resulting from another serious underlying pavement problem, the pavement can generally be considered structurally inadequate, and filling the ruts will not correct the problem. A pavement which has been in service for five years or less and has 25 mm (1 in) deep dual wheel track ruts in each wheel path generally has an unstable surface layer which will not be corrected by filling the ruts.



OPENING TO TRAFFIC GUIDELINES

Normally, micro-surfacing can handle rolling traffic in less than one hour after placement without damaging the pavement; stop-and-go traffic, especially heavy vehicles in cool, moist or very hot weather, may require additional curing time. Currently there are no quantifiable field tests to determine when traffic should be allowed on micro-surfacing. However, the following general information can assist in the decision.

THE SHOE TEST

The shear strength and bond can be checked subjectively by placing your full weight flatly on the sole of your shoe on the mixture. If the sole can be placed on the mixture for two seconds without picking up aggregate, then the pavement can be opened to rolling traffic without significant negative effects. If you place your weight on the heel of one shoe on the mixture and twist the heel (about 180°) with only minor surface marks and without the large aggregate being displaced, the mixture can probably be opened to turning traffic without significant damage. However, sharp turns, especially by heavy vehicles, can damage micro-surfacing for some time after application, especially in hot weather.

BREAKING AND CURING IN THE FIELD

How soon micro-surfacing is ready for traffic is a function of the time it takes the emulsion to break and the mixture to cure. The climatic conditions affect the curing time. Generally, as the temperature increases and the humidity decreases, it takes less time for the emulsion to break and expel the water. Cool, moist conditions, on the other hand, require longer curing times before opening to traffic. The emulsion should break after it has been placed on the surface, not in the mixing process. The material should be fluid enough to be spread evenly by the spreader box.

Climatic Conditions Affect Curing Time:

Temperature	Humidity	Break Time
increases	decreases	decreases
decreases	increases	increases

The emulsion should begin breaking no more than 30 to 45 seconds after the material is deposited by the spreader box. A small stick can be used to check for this.

Stick Test

Draw the stick through the mixture. Attempt to repair the resulting tear by smoothing the mixture with the stick.

Tear can be repaired by smoothing with a stick	emulsion has not broken
Tear cannot be repaired by smoothing with a stick	emulsion has broken

Section 2

QUALITY ASSURANCE GUIDELINES FOR MICRO-SURFACING

Introduction

BACKGROUND

The specification—a precise statement of requirements to be satisfied by a product, system, or service—functions as the link between TxDOT and the contractors and producers, describing exactly what is expected of all parties. Quality assurance testing is normally used to check that the desired quality product is delivered in accordance with the specification.

Micro-surfacing, as a material, appears to violate many of the techniques TxDOT inspectors have developed over the years to ensure that quality hot-mixed asphalt concrete pavements are constructed. For example, micro-surfacing requires that the surface be prewet, whereas normal hot mix asphalt application requires a dry surface.

PURPOSE

These guidelines were developed to give direction for the checks and tests during the application of micro-surfacing and thus ensure that a quality product is provided by the contractor. These procedures include:

- laboratory tests before and during the treatment application,
- checks to be conducted by TxDOT inspectors before and during the treatment application, and
- background and rationale on the use of the field observation checklist for quality assurance.

QUALITY ASSURANCE BEFORE CONSTRUCTION

The first step in designing a micro-surfacing mixture is the selection and testing of the mixture components. Checks and tests conducted before construction normally address the acceptability of the materials and mixture verification. All acceptance tests must be completed prior to beginning work.

MATERIALS ACCEPTANCE TESTS

In materials acceptance testing, the basic materials proposed for use by the contractor are tested to ensure they meet the specification requirements. The materials may be submitted by the contractor or collected by a TxDOT representative; however, they must be available to TxDOT in adequate time to allow all required tests to be completed prior to commencement of work. Testing may be completed at district or Materials and Tests Division laboratories.

Materials must be made available to TxDOT in adequate time to allow all required tests to be completed prior to commencement of work.

Polymer-Modified Emulsified Asphalt Cement

- Conduct tests to ensure that the polymer-modified emulsified asphalt cement meets the specification requirements.
- Determine the percentage of polymer in the distillation residue by Test Method TEX-533-C or other analytical method approved by TxDOT.

Aggregate

The mineral aggregate should:

- be composed of clean, tough, and durable particles of crushed trap rock, crushed granite, crushed sandstone, or other material approved by the engineer, and
- be produced by crushing operations from a single source.

Table 1 highlights the tests methods used to ensure that the requirements of specification are met for the aggregate.

Table 1: Aggregate Testing Requirements

Test Method Tex-203-F	Sand equivalent. Performed on the gradation to be used on the project.
Test Method Tex-411-A	Maximum weight loss when subjected to five cycles of conditioning using magnesium sulfate solution. Performed on the gradation to be used on the project.
Test Method Tex-438-A	Polish value test. Performed on the parent rock.
Test Method Tex-200-F, Part II	Washed sieve analysis gradation requirements.

Mineral Filler

- non-air-entrained portland cement which is free of lumps or foreign matter meeting the requirements of Item 524 of the *Texas Standard Specifications for Construction of Highways, Streets and Bridges*.

Water

- potable and
- free of harmful soluble salts.

Other Additives

The contractor defines what type of additive will be used with the micro-surfacing by revealing:

- chemical composition,
- brand name,
- additive designation, or
- other acceptable method.

MIXTURE DESIGN VERIFICATION

The contractor is responsible for providing the mixture design; however, TxDOT may check the mixture to verify that it meets the specification requirement. In the mixture design verification testing, TxDOT will conduct a series of tests on the basic materials. The materials must be available to TxDOT so that this verification can be completed prior to work starting. The mixture

design verification testing may be conducted at district or Materials and Tests Division laboratories. Once the mixture design is approved, all mixtures must meet the resulting job mixture formula. Table 2 shows the tests that will be performed in accordance with the TxDOT procedure to ensure that the mixture design provided by the contractor meets the current specifications.

Table 2: Mixture Design Verification Tests

Test Method Tex-240-F, Part I	"Mixing Time Test"
Test Method Tex-240-F, Part II	"Modified Cup Flow Test"
Test Method Tex-240-F, Part III	"Wet Cohesion Test"
Test Method Tex-240-F, Part IV	"The Wet Track Abrasion Test"

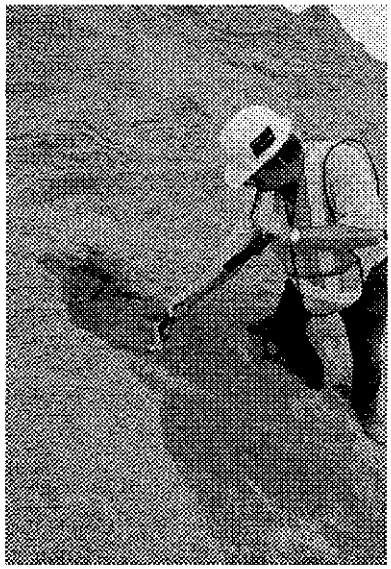
All tests will be conducted at the optimum, or average, mixture of components listed in the mixture design submitted by the contractor. The values from the tests (as shown in the specification) are based on the average test results from at least three samples for each test.

QUALITY ASSURANCE DURING CONSTRUCTION

This section of the manual includes guidelines on the conduct of materials and mixture tests and, where relevant, the use of the field observation checklist for recording information about workmanship (see appendix). The materials and mixture tests conducted during construction normally address whether the materials being placed meet the requirements established in the specifications and those which were approved in the checks and tests conducted prior to beginning construction.

MATERIALS TESTS

TxDOT inspectors normally collect material samples from the construction site and from the materials stockpile locations. Actual laboratory testing may be conducted at district or Materials and Tests Division laboratories. Any batch of material not meeting these requirements will be rejected, and any work completed using unacceptable material will be replaced.



TxDOT inspectors collect materials samples from the materials stockpile locations.

Polymer-modified emulsified asphalt cement

- Take and test one sample from each tanker load of emulsion or once each week, whichever is the larger number.
- Samples must be obtained in clean 1-gallon buckets. Prior to obtaining the sample, allow some emulsion to pour out of the emulsion tank into a 5-gallon bucket. This step is necessary to ensure a representative sample.
- Retain the sample for emulsion testing should it become necessary.

Aggregate

- Conduct tests on the representative aggregate samples taken from the job site stockpile.
- Complete one test for each stockpile established prior to commencement of micro-surfacing application or for every 900,000 kg (1000 tons) of aggregate delivered during treatment application.
- Include the amount of mineral filler added to the mix in determining the total minus 0.075 mm (No. 200) sieve aggregate fraction.

- Once the stockpiled material is accepted, only the gradation and sand equivalent tests will be required.
- Base the determination of aggregate gradation on sieve analysis of using Tex-200-F, Part II, "Washed Sieve Analysis."
- Conduct sand equivalent tests using Test Method Tex-203-F.
- Ensure that the aggregate does not vary from the design gradation by more than the tolerances shown in the specification. The material passing the 0.075 mm sieve is further restricted to conform to the limitations for the master grading for the type specified.

Mineral filler

Check to ensure that the non-air-entrained Portland cement is certified to meet the requirements of Item 524 of the *Texas Standard Specifications for Construction of Highways, Streets and Bridges*.

Water

Check to ensure that water is from an approved potable water source, unless otherwise allowed.

Additives

Check to ensure that additives match those identified by the contractor in the materials acceptance checks and tests.

MIXTURE COMPOSITION AND TOLERANCE TESTS

Mixture tests are conducted on samples of the micro-surfacing mixture taken from the micro-surfacing application machine. The contractor provides the proportions of all materials included in the mixture based on the readings from the equipment periodically throughout the day and cumulative at the end of the day.

1. Take one sample for every 900,000 kg (1000 tons) of mixture or once each day (whichever occurs first) from the mixing unit discharge in a pan or bucket of width such that the complete discharge stream is included in the sample.
2. Dry mixture samples to constant weight at 110°C (230°F) plus or minus 6°C (10°F) prior to determination of residual asphalt content.
3. Determine the residual asphalt content of the paving mixture in accordance with Test Method Tex-228-F (should not vary from the design amount by more than 0.5%).

USING THE FIELD OBSERVATION CHECKLIST

The field observation checklist should be used to collect and record information about limitations and workmanship as required in the specification. The following sections highlight information relevant to the quality assurance inspections and the checklist. To view the entire checklist, go to the appendix. Materials needed for the quality checks are:

- ruler or measuring tape capable of measuring to nearest 1 mm (1/16 in),
- 1.2 m (4 ft) straightedge (4 ft level is acceptable),
- stringline 30 mm (100 ft) or longer (a retractable line is convenient), and
- 30 m (100 ft) measuring tape or measuring wheel.

Weather Limitations

Rain on the mixture within 15 to 30 minutes after placement will not normally damage the mixture; however, if rain falls on the mixture before the emulsion has broken, the emulsion can be washed out of the mixture. Excessively cold temperatures can also be damaging.

Guidelines

Spread micro-surfacing material only when:

- the atmospheric temperature is at least 10°C (50°F) and rising, and
- the weather is not rainy.

Quality Check Procedure

1. Record minimum and maximum temperatures on a daily basis.
2. Record occurrence, extent, and duration of rain during and after construction as noted on the checklist (see Figure 1).

■ **WEATHER CONDITIONS**

Minimum Temperature _____(C) Maximum Temperature _____(C)

Rain During Construction? ☐ Yes ☐ No

Intensity of Rain	☐ Light	☐ Moderate	☐ Heavy
	(2.55 mm/hr)	(2.5 - 13 mm/hr)	(13 mm/hr)
	(< 0.1 in/hr)	(0.1 - 0.5 in/hr)	(> 0.5 in/hr)

Duration of Rain During Micro-surfacing Construction (minutes) _____

Length of Time After Construction Stopped Until Rain Began (minutes) _____

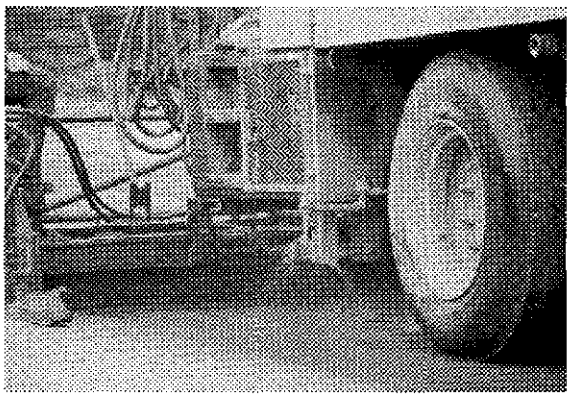
Comments: _____

_____

Figure 1

Surface Preparation

Vegetation, animal carcasses, loose aggregate, soil, and other debris can cause problems with the quality of the finished surface. It is also generally important for the surface to be slightly wet just as the micro-surface is spread; however, prewetting the surface on a flushed pavement is normally not done.



It is generally important for the surface to be slightly wet just as the micro-surface is spread; however, prewetting the surface on a flushed pavement is normally not done.

Guidelines

Spread micro-surfacing only when:

- the area to be surfaced is thoroughly cleaned, and
- the surface has been prewet at a rate to dampen the entire surface without creating free-flowing water ahead of the spreader box.

Quality Check Procedure

1. Note the condition of the surface—both in terms of moisture and cleanliness—prior to construction.
2. Note the distribution of moisture and debris according to checklist options (see Figure 2).

■ SURFACE PREPARATION

Surface cleaned of all vegetation, animal carcasses, loose aggregate, soil, and other debris.

Surface was: ❑ Clean ❑ Mostly Clean ❑ Somewhat Dirty ❑ Dirty

How was the condition described above distributed along the surface (check one)?

❑ Uniform ❑ Covers Most of Area ❑ Covers Some of Area ❑ Intermittent

Was the surface prewet ahead of speader box? ❑ Yes ❑ No

Moisture condition of surface ahead of spreader box:

❑ Dry ❑ Mostly Dry ❑ Somewhat Moist ❑ Moist

❑ Wet with Some Pooling ❑ Wet with Standing Water

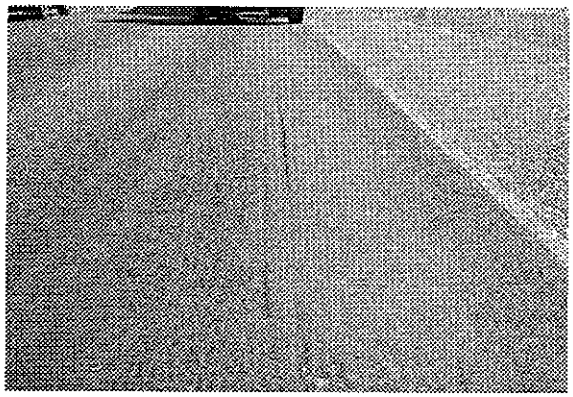
Comments: _____

_____

Figure 2

Surface Marks

The finished micro-surfacing should have a uniform texture free from excessive scratch marks, tears, or other surface irregularities.



Oversized particles of rock can become lodged under the strike-off device of the laydown box and, while being pulled along with the machine, leave a furrow in the surface.

Guideline

- Tear marks are considered excessive if there are four marks that are more than 12 mm (1/2 in) wide or wider, 150 mm (6 in) or more in length per 11 m² (120 sq ft), or any marks 25 mm (1 in) wide or wider and 100 mm (4 in) or more in length.

Quality Check Procedure

1. Measure any section one lane wide by 30 m (100 ft) long selected at random, and check at least one section for every four hours of work for surface marks.
2. Note number of tear marks in each sample as shown on the checklist (see Figure 3).
3. Any time that the surface appears to be unacceptable, check additional sections.

■ **SURFACE MARKS**

Number of tear marks greater than 12 mm (1/2 in) wide and longer than 150 mm (6 in) in a 3.7 m by 30 m (12 ft by 100 ft) area

Sample 1 _____ Sample 2 _____

Sample 3 _____ Sample 4 _____

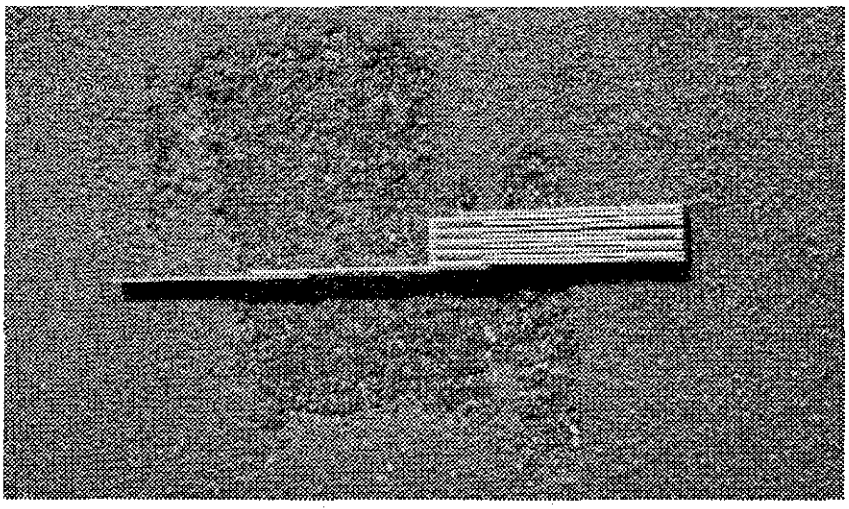
Number of tear marks greater than 25 mm (1 in) wide or wider, 100 mm (4 in) or more in length in a 3.7 m by 30 m (12 ft by 100 ft) area

Sample 1 _____ Sample 2 _____

Sample 3 _____ Sample 4 _____

Figure 3

Surface Loss



Sometimes the mixture does not correctly adhere to the surface.

Guidelines

- The mixture should adhere fully to the underlying pavement within one hour after application.
- Higher or lower temperatures may require longer curing time.

Quality Check Procedure

1. Measure any section one lane wide by 30 m (100 ft) long selected at random every four hours of work, and check for surface loss.
2. Note the measurement of surface loss as shown on the checklist (see Figure 4).
3. The same section used for surface marks can be used.
4. Any time that the surface appears to be unacceptable, check additional sections.

■ **SURFACE LOSS**

Area of surface loss in square meters (feet) in a 3.7 m by 30 m (12 ft by 100 ft) area

Sample 1 _____ Sample 2 _____ Sample 3 _____ Sample 4 _____

Figure 4

Handwork

Worker doing hand repair with squeegee/mop.

Guideline

- Areas of handwork should have a uniform texture that matches the texture and color of the finished surface produced by the spreader box.

Quality Check Procedure

1. Measure any section one lane wide by 30 m (100 ft) long selected at random every four hours of work, and check for surface characteristics.
2. Note measurement as shown on the checklist (see Figure 5).
3. The same section used for surface marks can be used.
4. Any time that handwork appears to be unacceptable, check additional sections.

■ **HANDWORK AREAS**

Area of surface worked by hand in unacceptable condition in a 3.7 m by 30 m (12 ft by 100 ft) area.

Sample 1 _____ Sample 2 _____

Sample 3 _____ Sample 4 _____

Comments: _____

_____

Figure 5

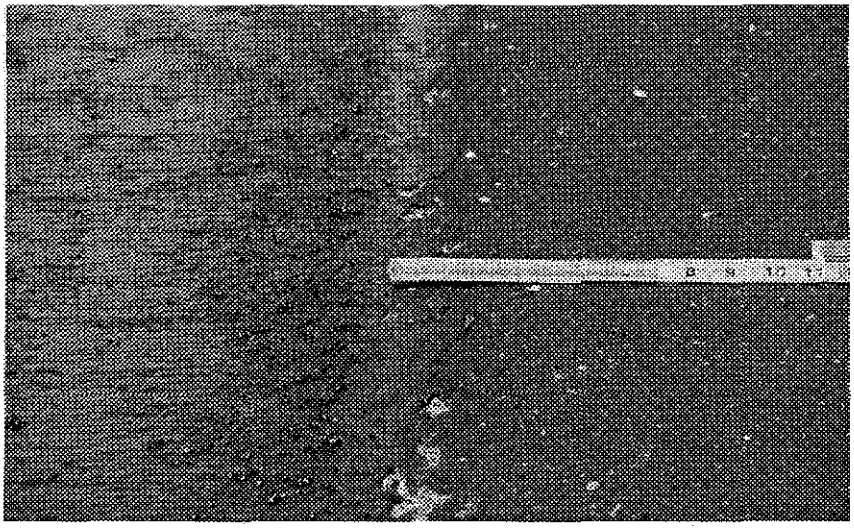
Joints/Seams

The longitudinal and transverse joints should appear neat and uniform. No excessive buildup, uncovered areas, gaps, or unsightly appearance will be permitted on longitudinal or transverse joints.

Transverse joints should be checked for bumps by measuring the gap between a 4 ft straight edge and the pavement.

Guidelines

- Place longitudinal joints on lane lines when possible.
- Joints will be considered acceptable if no more than a 12 mm (1/2 in) space exists between the pavement surface and a 1.2 m (4 ft) straight edge placed perpendicular on the longitudinal joint nor 6 mm (1/4 in) for a transverse joint.
- Joints with gaps or uncovered areas are not acceptable.



Unacceptable gap in longitudinal joint.

Quality Check Procedure

1. Measure any section 30 m (100 ft) long, and check at least one section for every four hours of work. Check all transverse joints.
2. Place end of 1.2 m (4 ft) straightedge on joint transverse to the direction of the joint (see Figure 6).
3. Note measurements between straightedge and pavement surface as shown on the checklist (Figure 7).
4. The same section used for surface characteristics can be used.
5. Any time that the joints and seams appear to be unacceptable, check additional sections.

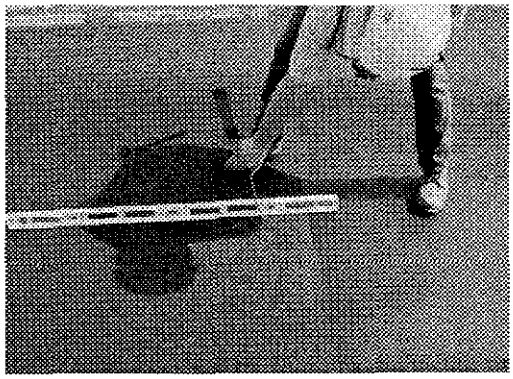


Figure 6

■ **JOINTS/SEAMS**

Select any section at random and check for joints and seams. A section is 30 m (100 ft) long. At least one section should be checked for each four-hours of work. The same section used for surface characteristics can be used. Any time that the joints and seams appear to be unacceptable, additional sections should be checked. ALL transverse joints constructed during a four hour period should be checked.

Longitudinal Joints

Were longitudinal joints placed on lane lines? ❑ Yes ❑ No

Maximum distance between surface and 1.2 m (4 ft) straightedge placed with one end on the longitudinal joint and the remainder across the lane in mm (in).

Location 1_____ Location 2_____ Location 3_____ Location 4_____

Length (m/ft) and width (mm/in) of gaps left between adjacent lanes

Location 1 Length _____Width_____ Location 3 Length_____Width ____
Location 3 Length _____Width_____ Location 4 Length_____Width ____

Transverse Joints

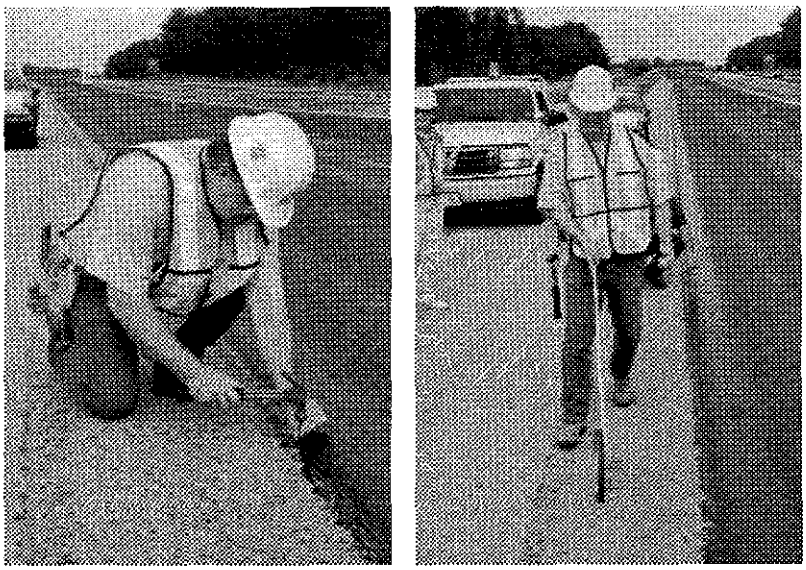
Maximum distance between surface and 1.2 m (4 ft) straightedge placed across transverse joint in mm (in)

Location 1_____ Location 2_____ Location 3_____ Location 4_____
Location 5_____ Location 6_____ Location 7_____ Location 8_____

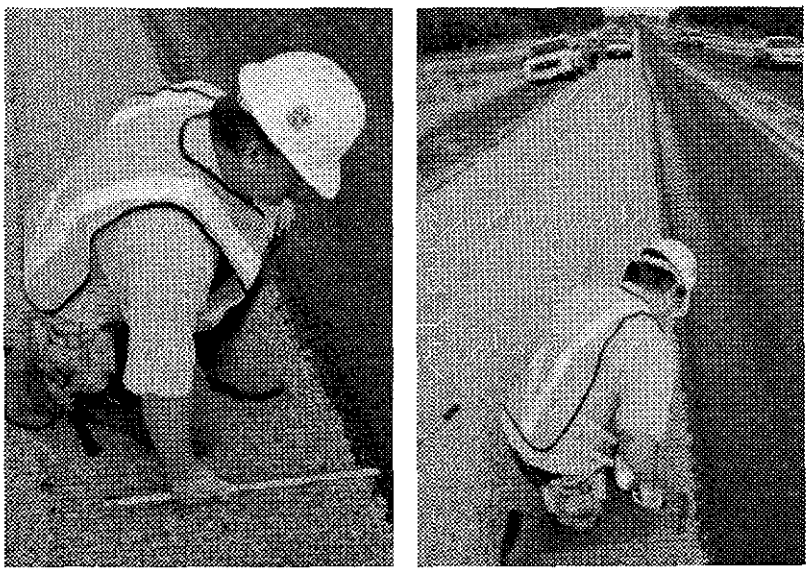
Comments:_____

_____

Figure 7



Lay a 30 m (100 ft) stringline along the edge of the micro-surfacing.



Measure any gaps between the string and the edge. The edge should vary no more than 75 mm (3 in).

Figure 8

Edges

The edges of the micro-surfacing should be uniform and neat appearing along the roadway centerline, lane lines, and shoulder or curb lines. A uniform cross section is defined as a pavement where the micro-surfacing is placed wider than the pavement and the pavement has no drop-offs greater than 12 mm (1/2 in) in the width in which the micro-surfacing is being placed. The edge is considered the line where the aggregate in the micro-surfacing mixture ends.

Guideline

- The edge should vary no more than plus or minus 75 mm (3 in) from a 30 m (100 ft) straight line on a straight section or from a 30 m (100 ft) arc of the design curve on a curved section.

Quality check procedure

1. Measure any section 30 m (100 ft) long, and check at least one section for every four hours of work (see Figure 8).
2. Note the measurement as shown on the checklist (see Figure 9).
3. The same section used for surface characteristics or joints and seams can be used.
4. Any time that the edges appear to be unacceptable, additional sections can be checked.

■ **EDGES**

Select any section at random and check edges. A section is 30 m (100 ft) long. At least one section should be checked for each four hours of work. The same section used for surface characteristics or joints and seams can be used. Any time that the edges appear to be unacceptable, additional sections should be checked.

Is the pavement or shoulder surface wider than the micro-surfacing being placed?
❑ Yes ❑ No

Is there a drop-off from the lane to the shoulder within the limits of the area being covered with micro-surfacing? ❑ Yes ❑ No

If yes, give maximum drop-off from the lane to the shoulder in mm (in):
Location 1_____ Location 2_____ Location 3_____ Location 4 _____

Is there a drop-off from the lane to the shoulder greater than 25 mm (1 in) within 150 mm (6 in) of the outside edge of the micro-surfacing? ❑ Yes ❑ No

If yes, give maximum drop-off from the lane to the shoulder in mm (in):
Location 1_____ Location 2_____ Location 3_____ Location 4 _____

Maximum distance in mm (in) the micro-surfacing edge varies from a 30 m (100 ft) straightedge on a straight section or from a 30 m (100 ft) arc of the design curve on a curved section (The edge of the micro-surfacing is considered where the edge of the aggregate in the micro-surfacing mixture ends. Stains from slight runoff of liquids should be expected along the edges.)
Location 1_____ Location 2_____ Location 3_____ Location 4 _____

Comments: _____

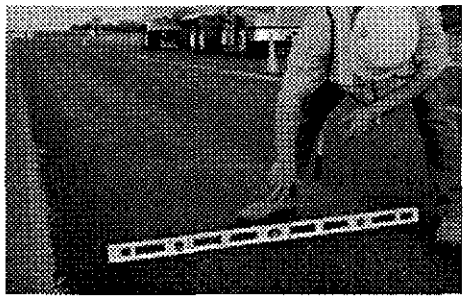
Figure 9

Ruts

When required on the plans, before the final surface course is placed, preliminary micro-surfacing material will be required to fill ruts, utility cuts, depressions in the existing surface, etc.

Guidelines

- Ruts of 12 mm (1/2 in) or greater depth shall be filled independently with a rut filling spreader box no more than 1.8 m (6 ft) in width.
- For irregular or shallow rutting less than 12 mm (1/2 in) in depth, a full-width scratch coat pass may be used as directed by the engineer.



Use a 1.2 m (4 ft) straightedge placed across the wheel path to measure lowest depth of the rut.

- Each individual rut filling, utilizing a rut filling spreader box, shall be crowned to compensate for traffic compaction.
- Ruts that are in excess of 25 mm (1 in) depth will require multiple placements with the rut filling spreader box to restore the original cross section.
- Maximum micro-surfacing thickness applied as rut filling in a single lift shall not exceed 25 mm (1 in).
- Maximum micro-surfacing placed full width of a lane shall not exceed 25 mm (1 in) in any location across the lane.
- At the end of construction, the transverse profile shall show no rutting in the wheel paths and no more than a 6 mm (1/4-in) height above the desired profile.

■ RUTS

Select any section at random and check four rutting. A section is one lane wide by 30 m (100 ft) long. At least one section should be checked for each four hours of work. Any time that the rutting appears to be unacceptable, additional sections should be checked. Measure in mm (in) depth to lowest portion of ruts after placing micro-surfacing using a 1.2 m (4 ft) straightedge placed across the wheel path of the pavement (if the height of the surface in the wheel path is higher than the desired profile, show as negative value.)

Location 1_____ Location 2_____ Location 3_____ Location 4_____
Location 5_____ Location 6_____ Location 7_____ Location 8_____

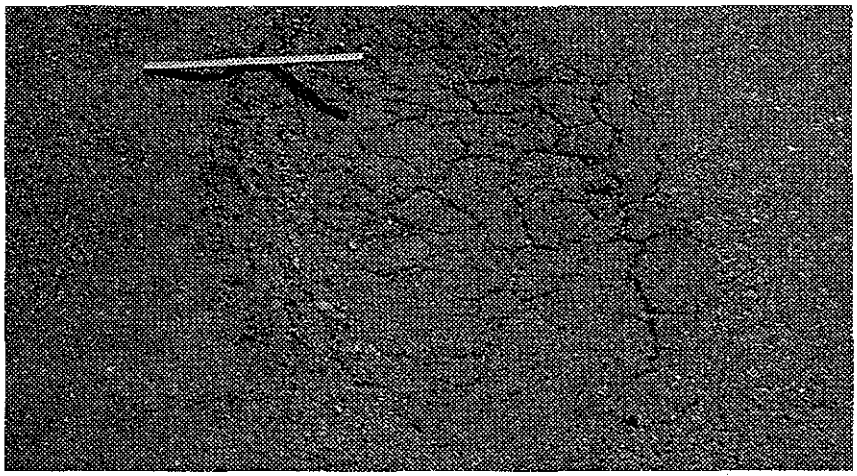
Comments: _____

_____

Figure 10

Quality Check Procedure

1. Measure any section one lane wide by 30 m (100 ft) long selected at random every four hours of work, and check for surface characteristics.
2. Note the measurements as shown on the checklist (see Figure 10).
3. The same section used for surface characteristics can be used.
4. Any time that the rutting appears to be unacceptable, additional sections can be checked.



Rutting over 25 mm (1 in) deep cannot be repaired with micro-surfacing.

Opening to Traffic

The micro-surfacing should be ready for traffic within the time required by specification. In intersections, crossing traffic may be allowed to use the intersection provided a thin layer of sand or micro-surfacing aggregate is spread on the fresh surface to protect it.

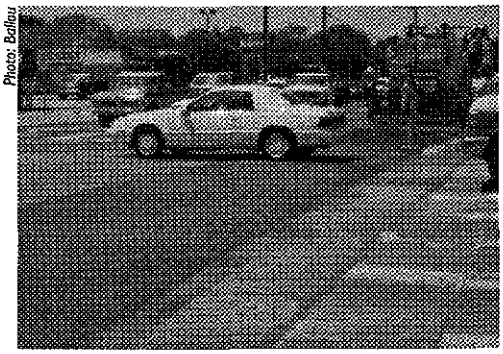


Photo: Ballou

When possible, cars should not be allowed on the micro-surfacing until it has fully cured, unless a thin layer of sand is spread for protection. Photo: Ballou

Guidelines

- Applying traffic should not significantly alter the surface.
- If a person's full weight can be placed flatly on the heel and sole of the shoe for about two seconds and no aggregate sticks to the shoe when lifted from the surface, rolling traffic can generally be allowed to use the surface without significant effects to the surface.
- If a person's full weight is placed flatly on the heel of a shoe on the surface and is twisted about 180° without the large aggregate being displaced, all types of traffic can generally be placed on the surface without a problem.

Quality Check Procedure

1. Each time traffic control is moved, check the time-to-opening damage to the surface.
2. Note the time from application that crossing and rolling traffic was applied, as shown on the checklist (see Figure 11).

■ **OPENING TO TRAFFIC**

Time from application until crossing traffic could be applied (minutes) _____

Time from application until rolling traffic could be applied (minutes) _____

Comments: _____

_____

Figure 11

Section 3

POSSIBLE PROBLEMS: PREVENTION AND CORRECTION

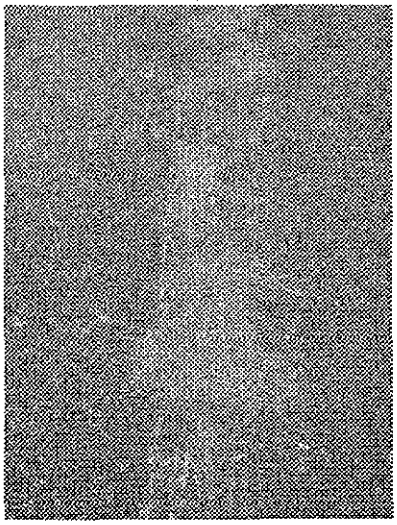
Introduction

This section is included because micro-surfacing is a maintenance process new to many TxDOT inspectors, who may not be familiar with the potential problems that can occur on a job. It is not intended for the inspector to make decisions for the contractor based on the information presented. Rather, the material is provided so that the inspector can recognize whether or not the contractor is making reasonable modifications to his work to prevent and/or correct problems. It also gives guidance on how to proceed if the contractor is not able to do so.

SURFACE PREPARATION

PROBLEM: The micro-surfacing delaminates, leaving areas with no surfacing.

PREVENTION: The original surface should be thoroughly cleaned prior to application of the micro-surfacing. The equipment must be well maintained and operated to prevent leaking oil, hydraulic fluid, or dry aggregate from contaminating the surface. Vegetation, animal carcasses, loose aggregate, soil, petroleum, and excessive water on the existing surface may reduce or prevent bond between the micro-surfacing and the existing pavement surface.



Surface delamination

CORRECTION: If the surface is not properly prepared, the contractor should be required to stop work. Work should not be restarted until the contractor demonstrates that the surface has been properly prepared.

FINISHED SURFACE

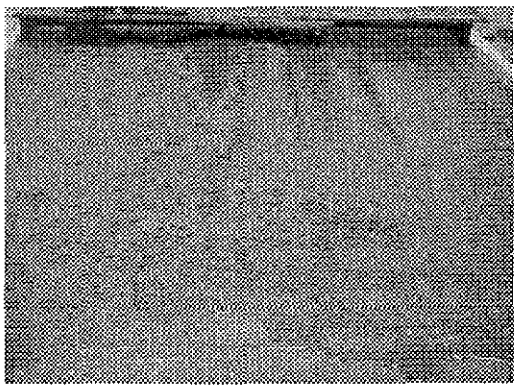
PROBLEM: Emulsion is breaking too fast, causing excessive drag marks and buildup in the application box.

PREVENTION: As the temperature increases, more additive must be used or the emulsion must be reformulated to provide the desired break time. Sometimes, the type of additive may have to be changed to control the breaking. A maximum of 0.5 percent additive is normally sufficient to reduce the breaking time to allow traffic on the micro-surfacing within the required time for the weather restrictions placed on micro-surfacing in Texas. If greater amounts are required, the emulsion should be reformulated since large increases can also affect the film thickness of the asphalt cement coating on the aggregate.

As the temperature increases, more additive must be used or the emulsion must be reformulated to provide the desired break time.

Cement is used in the mixture as a mineral filler and as a break rate controller. At normal cement rates of 0.25 to 2.0 percent, cement normally also acts as a break accelerator. The mixture design

normally establishes a cement content which will produce the break and strength gain needed based on laboratory conditions. As the temperature increases, however, this break rate may be too fast, and the contractor adds the special additive (generally more of the asphalt emulsifying agent) to reduce the break rate. As the atmospheric conditions change, more or less additive is used to control the break rate.



As the temperature increases, the break rate may be too fast, causing excessive drag marks and other serious problems.

On occasion, changes in water supply have caused the emulsion to break more quickly than expected based on laboratory designs. Water is not generally tested unless problems cannot be resolved otherwise. The water should be clean and potable to avoid problems. If water is suspected to be the cause of a problem, try another water source and see if the problem disappears.

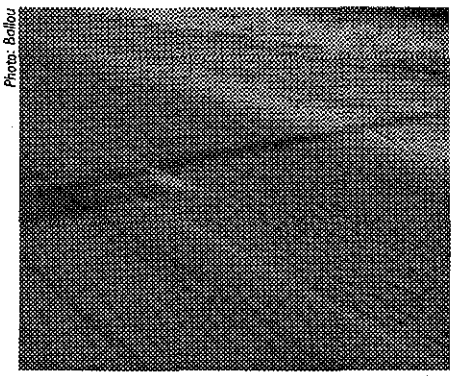
CORRECTION: If the mixture breaks too quickly due to high temperatures or problems with the water, the contractor should be required to stop work. Work should not be restarted until the contractor develops a mixture that will meet the requirements.

PROBLEM: Surface shows scratch and drag marks, tears, or other surface irregularities.

PREVENTION: Proper strike-off equipment, proper application rates, and a well-trained crew should be able to produce a high-quality surface. The type, thickness, and stiffness of the squeegee material on the back of the spreader box have an impact on the appearance of the final surface.

Micro-surfacing can be placed in layers more than twice the thickness of the nominal large aggregate; however, it is not possible to place it thinner than about 1.5 times the nominal maximum aggregate size without creating excessive drag marks. As the surface texture of the existing pavement becomes

Photo: Bidlou



Excessive drag marks and scratches.

more open, more material is required to meet this minimum thickness because the material must fill the voids in the existing surface, as well as provide the needed thickness. As the surface texture changes, the type, thickness, and stiffness of the squeegee material on the spreader box may have to be changed to developed the desired surface texture.

Rule of Thumb

The primary causes of scratch marks and tears are:

- trying to place the material in too thin of a layer,
- oversize aggregate in the mixture,
- not using enough additive during hot weather, and
- not cleaning the spreader box.

The aggregate should be handled and stockpiled carefully to ensure that oversized material is not allowed to mix with the micro-surfacing aggregate. Current specifications require use of a scalping screen in the aggregate feeding line to catch oversized aggregate before it enters the nurse trucks feeding the application equipment.

Some buildup of mixture will naturally occur in the spreader box, but it generally will remain attached to the spreader box during normal operation. When it dries sufficiently, the built-up mixture will break loose and fall into the mixture causing drag marks. Proper amounts of additive will reduce the amount of buildup in the spreader box. When dried material drops from the box into the mixture on a regular basis, this indicates that not enough special additive is being used in the mixture or there is a problem with the formulation of the emulsified asphalt cement.

The spreader box must be cleaned between each use and each time the application equipment stops. If it is not adequately cleaned, the buildup of hardened mixture will develop rapidly which will then break loose and cause drag marks.

CORRECTION: An experienced crew watching the application can repair small tears, damaged areas, and drag marks before the emulsion breaks using hand squeegees and drag mops. An experienced crew can also sometimes make hand repairs between double strike-offs so that they cannot be seen after the second strike-off passes over it.

Once the emulsion breaks, the mixture cannot be repaired without leaving an unsightly surface. Excessive repairs will cause the surface to be splotchy and unsightly. After a damaged area has dried, spot patches should not be allowed. All repairs completed after the material has broken should be completed using the machine and full-width coverage with the spreader box.

All repairs completed after the material has broken should be completed using the machine and full-width coverage with the spreader box.

spreader box. The repairs should be long enough to cover the damaged area, and the end joints should meet the requirements for transverse joints.

If the desired surface characteristics are not provided on occasion, the contractor should be required to repair them with a full-width coverage of the affected surface by micro-surfacing material using the standard equipment. If the desired surface characteristics are not provided on a regular basis, the contractor should be required to stop work. Work should not be restarted until the contractor demonstrates that the surface can be properly constructed on a test strip acceptable to the engineer.

JOINTS/SEAMS

PROBLEM: Longitudinal joints do not appear neat and uniform.

PREVENTION: No excessive build-up, uncovered areas, or unsightly appearance should be permitted. Longitudinal joints shall be placed on lane lines when possible. Excessive overlap (greater than 50 mm [2 in]) should not be permitted unless the width of the pavement is such that wider overlaps are required to keep the spreader box on the pavement surface. There should be no more than a 12 mm (1/2 in) space between the pavement surface and a 1.2 m (4 ft) straightedge placed on the longitudinal joint perpendicular to the joint. These spaces can generally be controlled if the operator is careful about the steering of the application equipment.

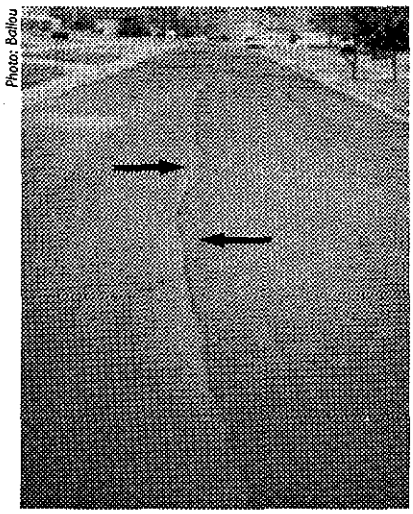


Photo: Ballou

Bad longitudinal joint.

Specification requires use of equipment with driving controls on both sides of the equipment so that the operator can follow the guidelines. Existing edge markings, string lines, and previously placed micro-surfacing in adjacent lanes may be used as the control. When the edge of the pavement is not uniform and the width of the micro-surfacing is equal to or less than the width of the pavement, the operator must follow that edge as closely as possible without allowing the box to travel off the edge of the pavement.

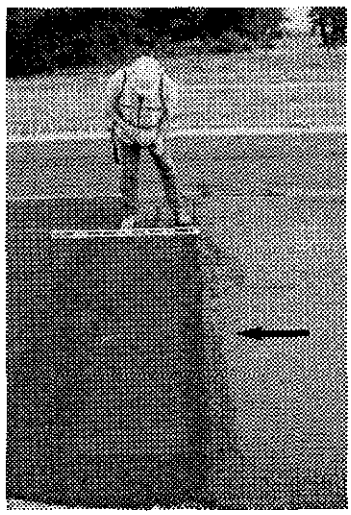
CORRECTION: Small gaps and slight overlaps between adjacent lanes can be corrected with squeegees or drag mops by the crew at the back of the equipment during placement.

If the desired joints and seams are not provided on occasion, the contractor should be required to repair them with a full-width coverage of the affected

surface by micro-surfacing material using the standard application equipment. If the desired joints and seams are not provided on a regular basis, the contractor should be required to stop work. Work should not be restarted until the contractor demonstrates that the joints and seams can be properly constructed on a test strip acceptable to the engineer.

PROBLEM: Transverse joints do not appear neat and uniform.

PREVENTION: No excessive build-up, uncovered areas, or unsightly appearance should be permitted. There should be no more than a 6 mm (1/4-in) space between the pavement surface and a 1.2 m (4 ft) straightedge placed on the transverse joint perpendicular to the joint in the wheel paths. Some contractors place metal strips on the existing micro-surfacing when starting the next pass to ensure that a clean joint with no buildup is provided. Every joint will provide some roughness and be somewhat noticeable; however, this should be minimized as much as possible.



Unacceptable transverse joint.

The total number of transverse joints, other than those required by bridges, other structures, and repairs, should be minimized and generally should occur no more often than one joint per 1.6 lane km (1 lane mi) based on the total length placed in the project. The contractor must coordinate the material requirements of his application equipment with the delivery capability of his nurse trucks and batch site to ensure that unnecessary stops are not made.

CORRECTION: If the desired joints and seams are not provided on occasion, the contractor should be required to repair them with a full-width coverage of the affected surface by micro-surfacing material using the standard application equipment. If the desired joints and seams are not provided on a regular basis, the contractor should be required to stop work. Work should not be restarted until the contractor demonstrates that the joints and seams can be properly constructed on a test strip acceptable to the engineer.

EDGES

PROBLEM: The edges of the micro-surfacing do not appear uniform and neat along the roadway centerline, lane lines, and shoulder or curb lines when placed on a pavement with a uniform cross section.

PREVENTION: A uniform cross section is defined as an area where the pavement width is greater than the width of the micro-surfacing placed and there are no drop-offs greater than 12 mm (1/2 in). The "edge" is considered where the edge of the aggregate in the micro-surfacing mixture ends. Slight runoff of liquids may be expected along the edges. More runoff may be expected on sections with super elevations or high crowns. Excessive runoff indicates excess water in the mixture.

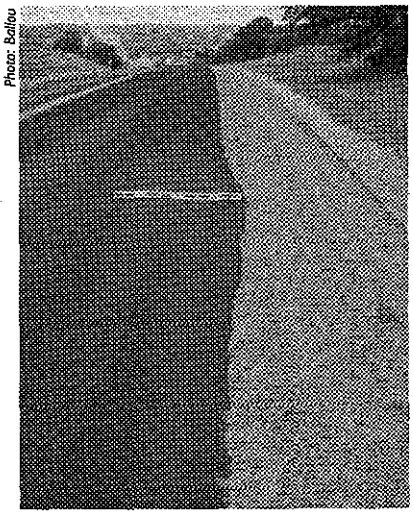


Photo: Ballou

Unacceptable edge.

When the pavement is wider than the micro-surfacing being placed, and the pavement has no drop-offs greater than 12 mm (0.5 in) near the edge of the micro-surfacing, the edge should vary no more than plus or minus 75 mm (3 in) from a 30 m (100 ft) straightedge on a straight section or from a 30 m (100 ft) arc of the design curve on a curved section. This can generally be adequately controlled if the operator carefully steers the application equipment. Existing edge markings, string lines, and previously placed micro-surfacing in adjacent lanes may be used as the control. Specification requires use of equipment with driving controls on both sides of the equipment so that the operator can meet the guidelines.

CORRECTION: If the desired edges are not provided on occasion, the contractor should be required to repair them with a full-width coverage of the affected surface with micro-surfacing material and using the standard application equipment. If the desired edges are not provided on a regular basis, the contractor should be required to stop work. Work should not be restarted until the contractor demonstrates that the edges can be properly constructed on a test strip acceptable to the engineer.

Existing edge markings, string lines, and previously placed micro-surfacing in adjacent lanes may be used as the control.

RUTS

PROBLEM: Rutting in the wheel path.

PREVENTION: Ruts of 12 mm (1/2 in) or greater depth should be filled independently with a rut-filling spreader box no more than 1.8 m (6 ft) in width. The rut-filling box can be used to crown the filled area; however, this crown should be limited to no more than 6 mm (1/4 in). Ruts in excess of 25 mm (1 in) depth generally require multiple placement passes with the rut-filling spreader box to restore the original cross section. If the material is placed too thick, excessive free moisture may be trapped between the micro-surfacing material and the existing pavement, reducing the bond between the existing pavement and the micro-surfacing material.

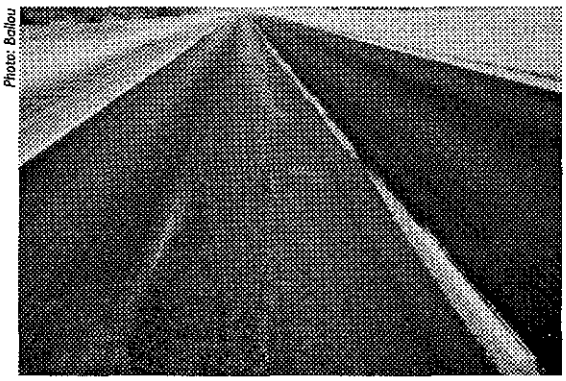


Photo: Ballou

Rut filling.

Maximum micro-surfacing thickness applied as rut filling in a single lift should normally not exceed 25 mm (1 in). For irregular or shallow rutting less than 12 mm (1/2 in) depth, a full-width scratch coat pass may be used. Maximum micro-surfacing placed full width of a lane should not exceed 25 mm (1 in) in any location across the lane. At the end of construction, the transverse profile should show no rutting in the wheel paths and no more than a 6 mm (1/4 in) height above the desired profile.

Rut filling should generally be considered a temporary maintenance treatment to restore the cross-section profile. It does not repair the cause of rutting but rather repairs the symptom. The "Usage Guidelines" try to provide guidance about when rut filling may be an appropriate maintenance treatment.

CORRECTION: If the desired profile is not provided on occasion, the contractor should be required to repair them with a full-width coverage of the affected surface by micro-surfacing material using the standard application equipment. If the profile is not provided on a regular basis, the contractor should be required to stop work. Work should not be restarted until the contractor demonstrates that the profile can be properly constructed on a test strip acceptable to the engineer.

Maximum micro-surfacing thickness applied as rut filling in a single lift should normally not exceed 25 mm (1 in).

OPENING TO TRAFFIC

The micro-surfacing should be ready for traffic within the time required by specification. When traffic is applied, the surface should not be significantly altered. Before opening to traffic, the emulsion must break, the mixture must gain shear strength, and the mixture must develop bond with the underlying pavement surface.

PROBLEM: The conditions in the field may be so cool and moist that the micro-surfacing will not break and cure quickly enough to allow traffic on it within the required time, even when no additive is being added to the mixture.

PREVENTION: Ambient temperature and moisture have an impact on the rate at which the emulsion will break and strength and bond develop in the mixture. The material should be spread only when the atmospheric temperature is at least 10°C (50°F) and rising, it is not raining, and there is no forecast of temperatures below 0°C (32°F) within 24 hours after mix placement. If it is too cool, the emulsion will not break or cure quickly enough to allow traffic on the mixture within a reasonable time period. If it rains on the mixture before the emulsion breaks, the mixture can be severely damaged.

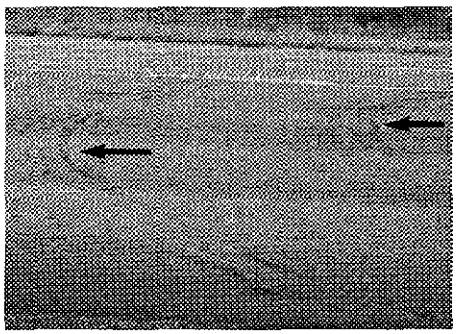
The material should spread only when the atmospheric temperature is at least 10° C (50° F) and rising, it is not raining, and there is no forecast of temperatures below 0° C (32° F) within 24 hours after mix placement.

The asphalt supplier may have to reformulate the emulsion so that it will break more quickly in the cool moist weather. For some mixtures, the amount of cement normally used can be increased to decrease the breaking time. This increase in cement should be based on the information from the mixture design. If too much cement is added, the emulsified asphalt cement in the micro-surfacing can break in the mixing chamber of the truck or in the spreader box. Trial increases are normally made in 0.5% increments based on dry weight of the aggregate until the required breaking time is achieved without breaking too fast. Generally, no more than 2.5% cement should be added to the mixture.

CORRECTION: If the desired break and strength gain do not develop adequately to allow the surface to be opened within contract time, the contractor should be required to stop work. Work should not be restarted until the contractor develops a mixture that will meet the requirements and demonstrates with a test strip that the surface can be opened in the required time.

PROBLEM: Surface shows deep tire marks.

PREVENTION: On occasion, a vehicle will drive across the micro-surfacing before it has gained adequate strength leaving deep tire marks. It may be possible to repair these with micro-surfacing material, but the marks will always show in the surface.



Early traffic can cause damage.

CORRECTION: Placing a second layer of micro-surfacing full width over the damaged area is the recommended repair method. This will only leave transverse joints which will eventually blend fairly well into the existing surface. Patching of tire marks is normally only required when the mark is all the way down to the existing surface. Minor marks are not normally patched.

PROBLEM: Stopped or slow-moving traffic pulls micro-surfacing loose, causing it to stick to vehicle tires.

PREVENTION: When weather is extremely hot and/or humid, opening time should be extended past the standard one-hour wait. This allows the micro-surfacing to properly bind.

CORRECTION: If an excessive amount of material is pulled off of the surface after traffic is applied, the contractor should be required to repair the area with a full-width coverage of the affected surface by micro-surfacing material using the standard application equipment.

NOTES