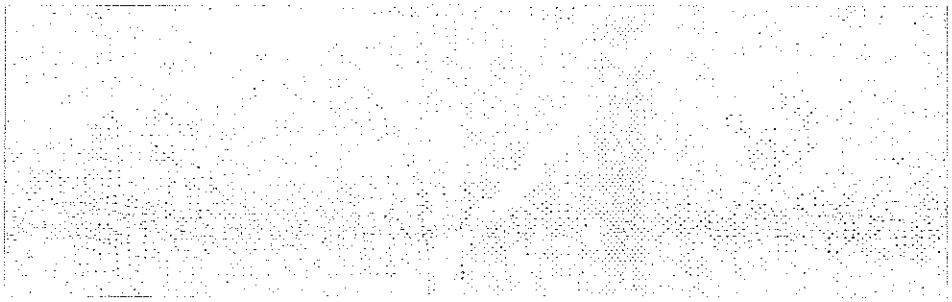
EVALUATION OF SLURRY SEAL SURFACE TREATMENT FOR APPLICATION ON THE MACKINAC BRIDGE

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION



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EVALUATION OF SLURRY SEAL SURFACE TREATMENT FOR APPLICATION ON THE MACKINAC BRIDGE

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Research Laboratory Section
Testing and Research Division
and the Construction Division
Research Project 78 TI-536
Research Report No. R-1200

Michigan Transportation Commission
Hannes Meyers, Jr., Chairman; Carl V. Pellonpaa,
Vice-Chairman; Weston E. Vivian, Rodger D. Young,
Lawrence C. Patrick, Jr., William C. Marshall
John P. Woodford, Director
Lansing, July 1982

Introduction

This project was initiated to evaluate the slurry seal process as a possible surface treatment for the bituminous lanes on the Mackinac Bridge. The existing cracks in the bituminous on the bridge are quite narrow with virtually no spalling evident. They appear to be of thermal and fatigue origin. Due to the nature of the cracking, it was believed that a surface treatment would be more efficient than the extensive work that would be required for removal and replacement of the existing asphalt. The presence of the adjacent coplanar steel grid surface on the suspended lanes rules out a standard overlay due to its thickness. This study is an attempt to find a thin surface treatment that will extend the life of the present surface until more extensive deterioration necessitates more permanent and extensive repairs.

Research Procedure

The work plan developed for this evaluation is attached as Appendix A and the "Special Provision" as Appendix B.

The site chosen for the evaluation was on M 1 (Woodward Ave) near 12 Mile Rd in Berkley (Fig. 1). The site was chosen because existing cracking and high traffic volumes would provide an intensive test for the process. It must be recognized that the base for the bituminous lanes on the Mackinac Bridge is a concrete-filled steel grid and, as such, allows no settlement or displacement. This is unique to a bridge location and comparable conditions on a roadway site are not available. Therefore, the large stresses induced on the roadway will not be as severe at the bridge location. Further, the cracking on the Woodward Ave surface was more frequent and cracks were of much greater width than those on the Mackinac Bridge.

As outlined in the work plan, six different slurry seal mixtures were to be placed in approximate 500-ft segments. During construction, one of the proposed mixtures was altered and a seventh mixture was added.

Construction

The experimental mixtures were placed July 6 and 7, 1981 by the Highway Maintenance and Construction Co. of Madison Heights, Michigan. The project engineer for the Department of Transportation was R. E. Coe and the inspector was B. Taylor.

Test areas 1, 2, and 3 were placed July 6, 1981. Test areas 1 and 2, both of which used anionic emulsion and natural sand, were removed before

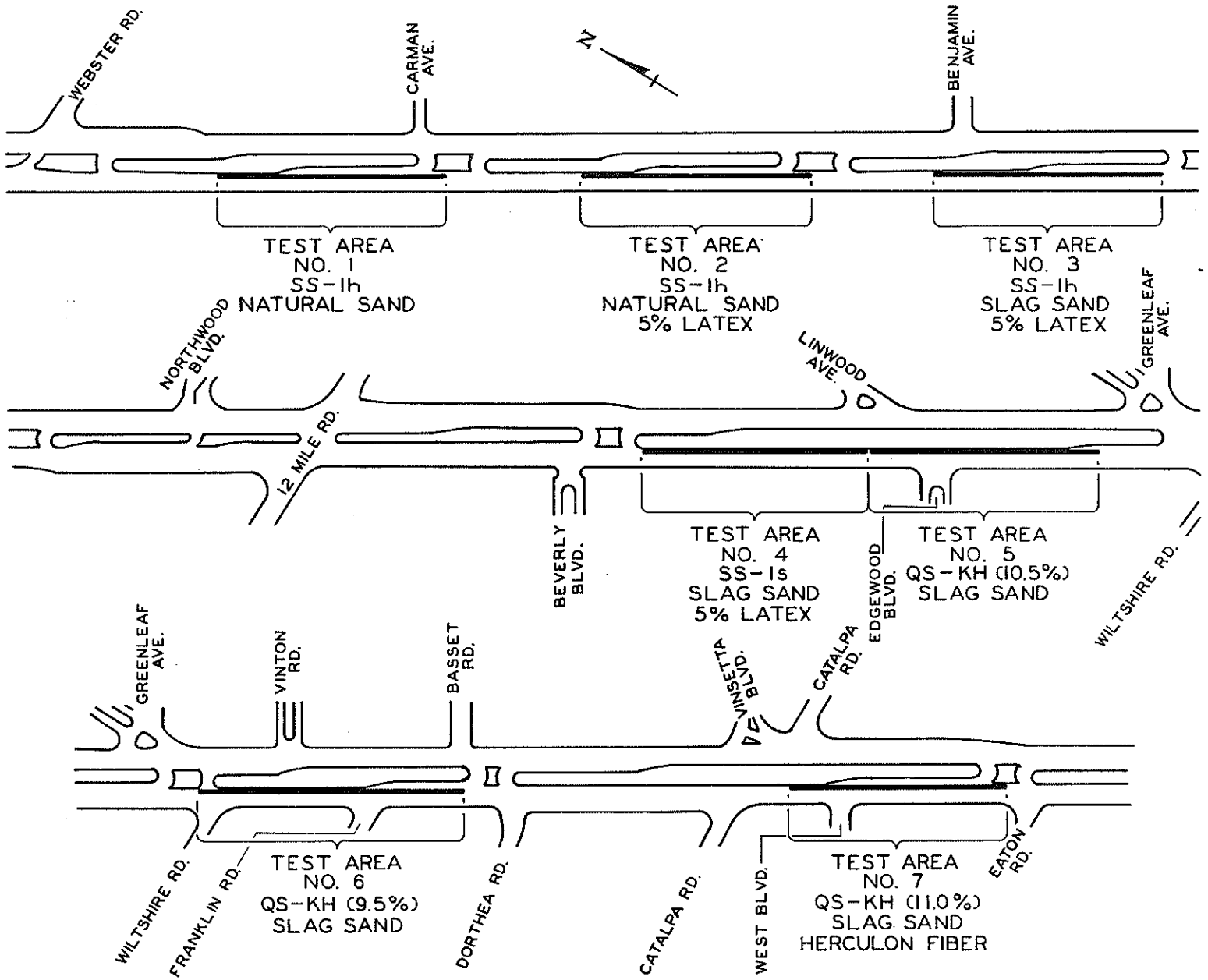

Figure 1. Location of slurry seal applications.

opening to traffic due to their unacceptably slow curing rate. Because of this experience, mixture 3, which was also an anionic emulsion and natural sand, was deleted. A mixture using cationic emulsion and slag sand was substituted in its place.

Test areas 4, 5, 6, and 7 were placed on July 7, 1981. Test area number 7 was an addition to the original work plan suggested by the contractor to evaluate the inclusion of Herculon fiber (a polypropylene fiber).

All of the mixtures were placed with a SM-8 Highway Slurry Machine. The only construction difficulties encountered were with the mixture containing Herculon. The fibers tended to "ball" the mixture and create uneven spreading. The mixture for test area 6 went down best. This mix is characterized by the contractor as his 'standard mix' and his familiarity with that material probably contributed to the ease of application. The cure rate was faster for the cationic emulsions (QS-KH) and that allowed a quicker reopening to traffic.

Performance

A visual examination was conducted April 28, 1982. The following is a general description of the performance of the seven test sections.

Test Area 1 - This section used SS-1h emulsion and natural sand (mixture 6 on the work plan). The slurry seal placed on this section was removed before opening to traffic because it did not cure within an acceptable period of time.

Test Area 2 - This section used SS-1h emulsion, natural sand, and 5 percent latex (mixture 1 on the work plan). The slurry placed on this section was also removed prior to opening to traffic because of an unacceptable curing rate.

Test Area 3 - This section used SS-1h emulsion, slag sand, and 5 percent latex (mix 2 on the work plan). This section exhibits some stripping and extensive cracking. Alligator cracking is in evidence with some spalling along the cracks.

Test Area 4 - This section used SS-1s emulsion, slag sand, and 5 percent latex (mixture 4 on the work plan). This section exhibits some minor stripping and extensive cracking. Some spalling has occurred along the cracks.

Test Area 5 - This section used QS-KH emulsion (10.5 percent) and slag sand. This mixture was a replacement for mixture 3 which was deleted based on experience with mixtures 1 and 6 which did not cure. The

mixture is similar to that used in test area 6 but had a higher emulsion content, 10.5 percent versus 9.5 percent for mixture 5. This section shows evidence of flushing which indicates an excessive bitumen content. Cracking occurs primarily only over the major cracks in the underlying surface.

Test Area 6 - This section used QS-KH emulsion (9.5 percent) and slag sand (mixture 5 on the work plan). Cracking occurs only over wide cracks in the underlying surface, cracks primarily caused by subsurface movement. This should not occur at the proposed bridge site.

Test Area 7 - This section used QS-KH emulsion (11.0 percent), slag sand, and Herculon fiber. This mixture was added by the contractor to evaluate the inclusion of Herculon fiber. The section exhibits considerable stripping, was difficult to mix the fiber uniformly, and tended to ball and hinder uniform spreading.

Pavement friction tests were conducted on the test areas October 11, 1981 and April 25, 1982. Results are as follows:

Section	Average Friction Number	
	October 11, 1981	April 25, 1982
3	43	46
4	44	45
5	41	43
6	45	46
7	42	45

Although all test areas exhibit cracking in varying degrees, it is believed that the cracking exhibited by test areas 5 and 6 are due to circumstances which will not be a factor on the proposed bridge site, i.e., relatively large movements of the underlying surface. The mix used on test area 5 would be eliminated, however, due to the flushing problem.

The resulting friction numbers are considered adequate for all sections and serve as no basis for choice of one section over another.

Conclusion

Based on the performance of the various mixtures after one winter, the mix used on test area 6, that is 9.5 percent QS-KH emulsion with slag sand, offers the most promise for application on the Mackinac Bridge. The

cracking that has occurred on this section should not occur on the bridge due to the nature of cracking and stability of the underlying surface. Although slag sand is probably not available in the area of the Mackinac Bridge and would require hauling, it is considered essential in the performance of the slurry.

APPENDIX A

EVALUATION OF SLURRY SEAL APPLICATION

Research Laboratory Section
Testing and Research Division
Research Project 78 TI-536
Work Plan No. 77R

Michigan Transportation Commission
Hannes Meyers, Jr., Chairman; Carl V. Pellonpaa,
Vice-Chairman; Weston E. Vivian, Rodger D. Young,
Lawrence C. Patrick, Jr., William C. Marshall
John P. Woodford, Director
Lansing, June 1980

The Problem

In a letter dated October 26, 1978, K. A. Allemeier requested the Research Laboratory comment on possible solutions for sealing cracks in the bituminous lanes of the Mackinac Bridge. This request was prompted by a letter dated October 24, 1978, from N. S. Walker to G. J. McCarthy.

M. G. Brown, R. A. Welke, C. J. Arnold, and F. Copple inspected the structure November 3, 1978, and found the bituminous surface in generally very good condition. The cracks are quite narrow with virtually no spalling evident, and appear to be of thermal and fatigue origin.

Since the deck is in good condition and the cracks are narrow, it is believed a slurry seal would be an acceptable solution and provide at least a few years of acceptable service. If after that time, further deterioration is observed, more permanent and expensive repairs should be considered.

Michigan has little experience with slurry seals. However, successful applications have been observed on several county and city roads in the State. This study is being proposed to gain experience and provide a basis for determining if the slurry seal is acceptable for use on the Mackinac Bridge.

If found acceptable, slurry seals should also be considered for other roadways where conventional overlays or reconstruction cannot be economically justified.

Scope

This work plan is proposed to evaluate six slurry seal mixtures for use as a maintenance seal on the Mackinac Bridge.

Mixture 1) SS-1h asphalt emulsion with natural sand aggregate and 5 percent latex rubber solids by weight based on asphalt solids.

Mixture 2) SS-1h asphalt emulsion with slag sand aggregate and 5 percent latex rubber solids by weight based on asphalt solids.

Mixture 3) SS-1s asphalt emulsion with natural sand aggregate and 5 percent latex rubber solids by weight based on asphalt solids.

Mixture 4) SS-1s asphalt emulsion with slag sand aggregate and 5 percent latex rubber solids by weight based on asphalt solids.

Mixture 5) QS-KH asphalt emulsion with slag sand aggregate.

Mixture 6) SS-1h asphalt emulsion with natural sand aggregate.

It is intended to place the slurry seals by early summer. Results evidenced by late spring 1981 should indicate whether any of the materials will suit our purposes.

Objectives

The study is designed to evaluate each of the slurry seal mixtures for their effectiveness in sealing cracks, durability, and adequate skid resistance.

Status of Known Research

Slurry seals have been used a great deal by local governments and counties as a low cost method of sealing roads and streets. Projects in Oakland County have served under heavy traffic for three and four years and have friction values above 0.50. However, nearly all of the work has been done with cationic emulsions.

Latex as a modifier of asphalt has been used with standard seal coats but not in slurry seals. Laboratory investigations have shown the latex to improve the adhesion and cohesion of the asphalt binder.

Research Procedure

The various materials will be placed in longitudinal test strips one lane wide by 500 ft in length.

Technical advice will be requested from J. F. Wood of the Midwest Asphalt Paving Corp., who has considerable experience in placing slurry seals. The sections will be visually evaluated for wear and skid tests will be conducted to determine friction levels maintained.

Project Supervision

This project will be a joint effort of the Testing and Research Division, Construction Division, and Maintenance Division. Project leader is R. L. Felter of the Research Laboratory.

Estimate of Cost

	1980	1981
Salaries and Wages	$500	$200
Travel and Subsistence	100	100
Report	---	100
TOTAL	$600	$400

APPENDIX B

SPECIAL PROVISION
FOR
EMULSIFIED ASPHALT SLURRY SEAL (TYPE I)

4.09.01 Description.-This work shall consist of preparing an existing surface and applying an emulsified asphalt slurry seal (Type I).

4.09.02 Materials.-The materials shall meet the requirements specified in Division 8 of the 1979 Standard Specifications for Construction (unless otherwise noted) as follows:

Aggregate 3CS, 3FS	8.02
Asphalt Emulsion SS-1h	8.04
Mineral Filler 3MF	8.02
Water	8.11

Asphalt Emulsion QS-KH

Viscosity at 77° F, Saybolt-Furol, sec.	20-50
Residue by Distillation, percent	57 min.
Sieve Test, retained on No. 20, percent	0.10 max.
pH	6.5 max.
Particle Charge	Positive

Tests on Residue from Distillation

Penetration at 77° F, 100g, 5 sec.	40-90
Solubility in Trichloroethylene, percent	97.5 min.
Ductility at 77° F, cm	40 min.

The type and quantities of materials to be used for a specific slurry seal shall be as specified on the plans or in the proposal.

4.09.03 Equipment.-The suitability and condition of all equipment shall meet the approval of the Engineer before work is started.

A. Slurry Mixing Equipment.-The slurry mixing machine shall be a continuous flow mixing unit and be capable of delivering accurately a predetermined proportion of aggregate, water, and asphalt emulsion to the mixing chamber and of continuously discharging the thoroughly mixed product. The aggregate shall be prewetted immediately prior to mixing with the emulsion. The mixing unit of the mixing chamber shall be capable of thoroughly blending all ingredients together. No violent mixing shall be permitted.

The mixing machine shall be equipped with an approved fines feeder that provides an accurate metering device or method to intorduce a predetermined proportion of mineral filler into the mixer at the same time

and location that the aggregate is being introduced. The fines feeder shall be used whenever added mineral filler is a part of the aggregate blend.

The mixing machine shall be equipped with a water pressure system and fog type spray bar adequate for complete fogging of the surface preceding the spreading equipment.

B. Slurry Spreading Equipment.-Attached to the mixing machine shall be a mechanical type squeegee distributor equipped with a flexible strike-off that is in contact with the surface to prevent loss of slurry from the distributor. The spreading equipment shall be maintained so as to assure uniform spread. The spreader box shall have an adjustable width. The box shall be kept clean, and build-up of asphalt and aggregate on the box shall not be permitted. The use of burlap drags or other drags shall be used only when approved by the Engineer.

C. Cleaning Equipment.-Power brooms, power blowers, air compressors, water flush equipment, and hand brooms shall be suitable for cleaning the surface and cracks of the old surface, as approved by the Engineer.

D. Auxiliary Equipment.-Hand squeegees, shovels, and other equipment shall be provided as necessary to perform work.

4.09.04 Preparation of Surface.-Immediately prior to applying the slurry, the surface shall be cleaned of all loose material, silt spots, vegetation, and other objectionable material. Any standard cleaning method used to clean pavements will be acceptable, except water flushing will not be permitted in areas where many cracks are present in the pavement surface.

If the slurry is being placed over a brick or concrete surface, highly absorbent asphalt surface, or over a surface where the aggregate has become exposed and is polished and slick, a 1 part emulsion, 3 part water, tack coat of the same asphalt emulsion type and grade as specified for the slurry will be required.

This can be applied with an asphalt distributor or suitable water truck. The normal application rate is 0.05 to 0.10 gallons of the diluted emulsion per square yard of surface.

The prepared surface must meet with the approval of the Engineer.

4.09.05 Construction Methods.-The surface shall be prewetted by fogging with water ahead of the slurry box if required by the Engineer. Water used in prewetting the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the slurry box. The slurry mixture shall be of the desired consistency when deposited on the

surface and no additional elements shall be added. Total time of mixing shall not exceed four minutes. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained. No lumping, balling or unmixed aggregate shall be permitted. Segregation of the emulsion and aggregate fines from the coarse aggregate will not be permitted. If segregation occurs upon discharge, the slurry will be removed from the pavement. Excessive breaking of the emulsion will not be allowed in the spreader box. Streaks such as caused by oversized aggregate will not be allowed in the finished pavement.

Excessive build-up or unsightly appearance will not be permitted on longitudinal or transverse joints.

Approved squeegees shall be used to spread slurry in areas inaccessible to the slurry mixer. Care shall be exercised in leaving no unsightly appearance from hand work.

Treated areas will be allowed to cure until such time as the Engineer permits their opening to traffic.

4.09.06 Weather Limitations.-The slurry seal surface shall not be applied if either the pavement or air temperature is 55° F or below and falling, but may be applied when both the air and pavement temperature is 45° F or above and rising. The mixture should not be applied if high relative humidity prolongs the curing beyond a reasonable time.

4.09.07 Method of Measurement.-The emulsified asphalt slurry seal (Type I) will be measured in square yards.

4.09.08 Basis of Payment.-The completed work as measured for EMULSIFIED ASPHALT SLURRY SEAL (TYPE I) will be paid for at the contract unit price for the following contract item (pay item).

Pay Item	Pay Unit
Emulsified Asphalt Slurry Seal (Type I)	sq yd

The price shall be payment in full for furnishing, mixing, and applying the materials according to this specification.

SPECIAL PROVISION
FOR
LATEX MODIFIED EMULSIFIED ASPHALT SLURRY SEAL (TYPE I)

4.09.01 Description.-This work shall consist of preparing an existing surface and applying a latex modified emulsified asphalt slurry seal (Type I).

4.09.02 Materials.-The materials shall meet the requirements specified in Division 8 of the 1979 Standard Specifications for Construction (unless otherwise noted) as follows:

Aggregate 3CS, 3FS	8.02
Asphalt Emulsion SS-1h, SS-1s*	8.04
Mineral Filler 3MF	8.02
Water	8.11

Latex Rubber Compound

The rubber compound to be used in the asphalt emulsion shall be an approved unvulcanized virgin synthetic rubber in the liquid anionic latex form. The Manufacturer of the rubber compound shall provide a written certification showing the target value for total rubber solids content of the rubber compound and containing test results showing compliance with the following requirements for ash content and viscosity:

Allowable Range of Target Value for Total Rubber Solids, percent by weight	45-65%
Allowable Variation from Target Value for Total Rubber Solids, percent by weight	± 1%
Ash, Percent of Total Rubber Solids, ASTM D297, max.	3.5
Viscosity, Brookfield Units, Model RVF, Spindle No. 2 at 20 rpm at 25C, max.	800

The Latex Rubber Compound shall be mixed with the asphalt emulsion prior to the asphalt emulsion being discharged into the mixing chamber.

The type and quantities of materials to be used for a specific slurry seal shall be as specified on the plans or in the proposal.

4.09.03 Equipment.-The suitability and condition of all equipment shall meet the approval of the Engineer before work is started.

A. Slurry Mixing Equipment.-The slurry mixing machine shall be a continuous flow mixing unit and be capable of delivering accurately a

* Except that the penetration of the SS-1s residue shall be 100-150.

predetermined proportion of aggregate, water, and asphalt emulsion to the mixing chamber and of continuously discharging the thoroughly mixed product. The aggregate shall be prewetted immediately prior to mixing with the emulsion. The mixing unit of the mixing chamber shall be capable of thoroughly blending all ingredients together. No violent mixing shall be permitted.

The mixing machine shall be equipped with an approved fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer at the same time and location that the aggregate is being introduced. The fines feeder shall be used whenever added mineral filler is a part of the aggregate blend.

The mixing machine shall be equipped with a water pressure system and fog type spray bar adequate for complete fogging of the surface preceding the spreading equipment.

B. Slurry Spreading Equipment.-Attached to the mixing machine shall be a mechanical type squeegee distributor equipped with a flexible strike-off that is in contact with the surface to prevent loss of slurry from the distributor. The spreading equipment shall be maintained so as to assure uniform spread. The spreader box shall have an adjustable width. The box shall be kept clean, and build-up of asphalt and aggregate on the box shall not be permitted. The use of burlap drags or other drags shall be used only when approved by the Engineer.

C. Cleaning Equipment.-Power brooms, power blowers, air compressors, water flushing equipment, and hand brooms shall be suitable for cleaning the surface and cracks of the old surface, as approved by the Engineer.

D. Auxiliary Equipment.-Hand squeegees, shovels, and other equipment shall be provided as necessary to perform work.

4.09.04 Preparation of Surface.-Immediately prior to applying the slurry, the surface shall be cleaned of all loose material, silt spots, vegetation, and other objectionable material. Any standard cleaning method used to clean pavements will be acceptable, except water flushing will not be permitted in areas where many cracks are present in the pavement surface.

If the slurry is being placed over a brick or concrete surface, highly absorbent asphalt surface, or over a surface where the aggregate has become exposed and is polished and slick, a 1 part emulsion, 3 part water, tack coat of the same asphalt emulsion type and grade as specified for the slurry will be required. This can be applied with an asphalt distributor or suitable water truck. The normal application rate is 0.05 to 0.10 gallons of the diluted emulsion per square yard of surface.

The prepared surface must meet with the approval of the Engineer.

4.09.05 Construction Methods.-The surface shall be prewetted by fogging with water ahead of the slurry box if required by the Engineer. Water used in prewetting the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the slurry box. The slurry mixture shall be of the desired consistency when deposited on the surface and no additional elements shall be added. Total time of mixing shall not exceed four minutes. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained. No lumping, balling or unmixed aggregate shall be permitted. Segregation of the emulsion and aggregate fines from the coarse aggregate will not be permitted. If segregation occurs upon discharge, the slurry will be removed from the pavement. Excessive breaking of the emulsion will not be allowed in the spreader box. Streaks such as caused by oversized aggregate will not be allowed in the finished pavement.

Excessive build-up or unsightly appearance will not be permitted on longitudinal or transverse joints.

Approved squeegees shall be used to spread slurry in areas inaccessible to the slurry mixer. Care shall be exercised in leaving no unsightly appearance from hand work.

Treated areas will be allowed to cure until such time as the Engineer permits their opening to traffic.

4.09.06 Weather Limitations.-The slurry seal surface shall not be applied if either the pavement or air temperature is 55° F or below and falling, but may be applied when both the air and pavement temperature is 45° F or above and rising. The mixture should not be applied if high relative humidity prolongs the curing beyond a reasonable time.

4.09.07 Method of Measurement.-The latex modified emulsified asphalt slurry seal (Type I) will be measured in square yards.

4.09.08 Basis of Payment.-The completed work as measured for LATEX MODIFIED EMULSIFIED ASPHALT SLURRY SEAL (TYPE I) will be paid for at the contract unit price for the following contract item (pay item).

Pay Item	Pay Unit
Latex Modified Emulsified Asphalt Slurry Seal (Type I)	sq yd

The price shall be payment in full for furnishing, mixing, and applying the materials according to this specification.