BLAST FURNACE SLAG SLURRY SEALS

I. Purpose

This publication has been prepared by the National Slag Association to provide a condensed reference document for NSA members and slurry contractors who plan to use slag slurry and have not had extensive experience in the use of slag in slurry. It highlights some of the important aspects of slurry seals pertinent to both the slag processor and to the contractor, and addresses some of the questions and allegations which sometimes develop when slag is used in slurry.

Slag slurry has been used successfully, and is preferred by some contractors; others have had difficulties. These problems are not caused by the use of slag in most instances. In those cases where they are, it is believed they are the result of misunderstandings concerning, or inexperience with, simple, but critical, aspects of slurry.
This document is intended to provide information which will help to prevent the occurrence of difficulties and to identify important aspects of slurry design and placement which must be considered.

Information herein is an initial consolidation of data and opinions obtained from NSA members who have had good experience with slag slurry, individual slurry contractors and the International Slurry Seal Association (ISSA). It is anticipated that supplements will be published periodically.

II. BACKGROUND

Slurry seals were developed, in the late 1920's and the early 1930's. Using an asphalt emulsion with a fine aggregate and filler, a "slurry" or semi-fluid mix was prepared, usually in a transit mix truck. The slurry was then dumped into a spreader box towed behind a truck or tractor. The procedure met with only limited success, one of the greatest problems being lack of adhesion to the old pavement surface. It was believed that extended periods of mixing and agitation caused the asphalt emulsion to partially "break" before placing on old pavement, thus decreasing its ability to adhere to the worn surface.

In 1960, the first commercially available self-contained machine to continuously mix and spread slurry seals was placed in operation. This permitted quick proportioning, mixing, and placing of the slurry before the emulsion started to break, thus improving adhesion to the old surface. Five or six companies now manufacture such equipment. Excessively long curing times and improper use of slurry seals, however, in applications where structural failures were the basic problems resulted, in poor performance and limited use of this maintenance technique for a number of years.

Recently, however, the improvement of anionic and the development of cationic quick set emulsions has provided a mean's to control the time required for the emulsion to "break" and has alleviated the "curing time" problem. This development, combined with better job controls and specifications, laboratory evaluation of materials and mixes,
improved asphalt emulsions, recognition of the proper types of uses for slurry surfaces to accompany the self-contained machines, the shortage and high cost of bitumen and the reduction in funds available for reconstruction of roads could result in a major increase in the use of slurry seals.

III. SPECIFICATIONS

Specifications for slurry seals were first developed by the slurry machine manufacturers and later modified and adopted by the International Slurry Seal Association. The specifications of ISSA and ASTM should be used as basic reference documents.

General requirements or descriptions of slurry seals in the specifications usually stipulate that they shall consist of' mixtures of emulsified asphalt and fine mineral aggregate, with water and/or mineral filler when needed for workability or proper aggregate gradation, uniformly mixed and spread on the prepared surface. In some cases the

Stipulation is also included that “the cured slurry shall have a homogeneous appearance, fill all surface voids and penetrate cracks, adhere firmly to the surface, and have a skid resistant texture."

IV. TYPES AND USES OF SLURRY

Three types of slurry seal mixes are commonly used with variations in aggregate grading, asphalt content and application rate. The most commonly used, however, is type II. Each is intended for specific types of applications. Table 1 shows the combined aggregate gradations (including filler, if used) and residual asphalt contents for these three types of mixes.

Table 1 Types of Slurry Commonly used and specified by International Slurry Seal Association Guide Spec A-105

Sieve Size	Type I	Type II	Type III
$^3/_8$	100	100	100
#4	100	90 -100	70 – 90
#18	90 – 100	65 – 90	45 – 70
#16	65 – 90	45 – 70	28 – 50
#30	40 – 60	30 – 50	19 – 34
#50	25 – 42	10 – 30	12 – 25
#100	15 – 30	10 – 21	7 – 18
#200	10 – 20	5 – 15	5 - 15
Residual Asphalt Content - % Dry Agg	10 - 16	7.5 – 13.5	6.5 - 12

Type I. (Fine Surface Mixes) This aggregate blend is used to seal cracks, fill small voids, and correct moderate surface deterioration and/or general drying or hardening of surface asphalt. The approximate application rate is 6 to 10 ld/sq.yd based on dry aggregate weight. The fineness of this design provides it with maximum crack penetrating properties. A typical example of use for this type of slurry surface would, is on airfields, interstate shoulders, or other areas where protection from effects of weathering is the primary concern. It can be used in lieu of a prime or tack coat.

Type II. (General Surface Mixes) This aggregate blend is the most commonly used in slurry seal work and most closely corresponds to the grading of most slag screenings. They are used when it is desired to fill surface voids, correct surface erosion and ravelling, and provide sealing and a thin wearing surface. When surface voids or cracks are large, they should be filled with a Type II or III slurry before applying the slurry to the entire surface. The application rate is approximately 10 to 20 lb/sq yd based on dry aggregate weight. These mixes are widely used on airfields, highway shoulders, streets, parking lots, and where improved skid resistance is necessary. They may also be used as a light wearing surface on stabilized base courses or as a sealer on bases prior to final paving.

Type III. (Coarse Surface Mixes) This aggregate blend uses aggregates up to 3/8" in size and are applied at rates above 15 lb/sq yd. Major applications are for extremely rough textured pavements where a larger size of aggregate and a greater slurry thickness are necessary to fill in the voids and provide a moderate thickness wearing course. They may also be used in two course construction to correct the crown in a pavement or to provide a wearing course on various types of stabilized bases, including soil cement.

It should be noted that slurry seals are designed to seal cracks, fill surface voids and correct surface deterioration, provide a new light-to-moderate duty wearing surface and improve skid resistance. They cannot and should not be expected .to compensate for structural inadequacies, base or sub grade failures, etc. All such areas should be suitably patched and strengthened prior to application of the slurry seal.

V. MATERIALS

Material requirements are usually identical to those for other paving applications except as noted below.

1. Asphalt Emulsions may be either Cationic or Anionic and are made with selected asphalt. ASTM D977 and D2997 cover standard specifications for SS-1, SS-1H CSS-1 or CSS1H. Cationic quick set emulsions designated in some states as CQS-1H or QSKH, are gaining in popularity because of their quick setting and rain resistant properties.

2. Aggregates are required to meet quality requirements such as those of ASTM D1073, Standard Specification for Fine Aggregate for Bituminous Paving Mixtures, except with respect to gradation and an added requirement in most slurry seal specifications requiring a high percentage of crushed particles. Crushed aggregates are therefore, used in nearly all slurry mixes, blended with fillers as necessary to meet the required mix grading arid mix behavior characteristics.
3. Fillers when used, should meet, ASTM D242 (Standard Specification for Mineral Filler for Bituminous, Paving Mixtures) requirements. While a variety of fillers have been used in slurry seal work, Portland cement is probably the most common. Filler when used is usually 0.5 to 3.0% of the total aggregate. Several contractors have found that no cement, or other filler, is necessary when some slags are used and grading is uniform and has adequate - #200 mesh (opinions vary on adequate % from 8 to 12). However, in some cases cement fillers may be necessary as indicated by

laboratory design. When fly ash is used as filler it is important that tests be made to insure that it is compatible with the emulsion to be used - sometimes they are not. Some contractors are of the opinion that use of more than 1% flash will significantly reduce skid resistance due to the hard rounded surfaces of flash. Hydrated lime also can be used as filler.

VI. MIX DESIGN

1. THE IMPORTANCE OF A PROPERLY PERFORMED MIX DESIGN CANNOT BE OVER-EMPHASIZED! Proper design is not difficult but suitability and compatibility tests must be performed on all materials proposed for the slurry. Most emulsion suppliers are equipped to, and willing to, make such tests. In any event, they should be conducted in a laboratory equipped to make these tests, and, preferably one which, has had experience with slurry designs and is familiar with the special characteristics of slag.
2. The design of a slurry mix must consider factors other than the materials being used, e.g., older surfaces to be covered must have more bitumen in the mix to compensate for the blotting action of the old surface, and higher ADT surfaces require less bitumen than lower ADT due to kneading and compaction of traffic.
3. One of the most important initial design actions is the determination of the optimum amount of emulsion needed. Since this determination is governed to a considerable degree by surface area of aggregate, it is especially important for slag because of its vesicular structure. Many slurry contractors and design laboratories use the Centrifuge Kerosene Equivalent test for this purpose. Following the laboratory determination of the proper ratio for emulsion to aggregate, the optimum water for mixing is obtained by a consistency test such as the Slurry Seal Inc. Inclined flow, Kansas Cone flow or ISSA funnel flow methods. The aggregate used in this test is usually in an air dried condition.
4. Slag is compatible with most cationic or anionic emulsions, as are natural aggregates; however, tests must be made to ensure that the proper "emulsion" is used. Slurry emulsions are especially sensitive to pH and chemical characteristics of aggregates. Emulsifiers suitable for any type of aggregate are available, but test must be made to confirm compatibility of type of asphalt emulsion to be used. THIS IS A VITAL DESIGN ACTION WHEN SLAG IS USED.
5. The optimum utilization of bitumen occurs in a very small range of minus #200, plus or minus 1% from the optimum percentage of minus #200. A minimum amount of minus #200 is required to provide adequate matrix for the larger pieces but excessive minus #200 only blots up the bitumen without providing any additional binding for the larger particles.

6. If not enough minus #200 is provided, the bitumen content must be increased to lock in larger particles. This may lead eventually to flushing of the surface. Less than optimum fines in the mix also may cause popouts of the larger particles due to inadequate matrix for binding the larger particles in place. There is a consensus of opinion that at least 50% of each aggregate particle should be imbedded in the matrix to avoid excessive "tear-out".
7. While acceptable slurry can be made with minus #200 below 10%, there is some opinion that slurry having the greatest longevity will have a minus #200 percentage in a range of 10-12%.
8. Setting time is determined by checking the time required before slurry using the selected proportions will no longer transfer a brown stain to a paper towel pressed against it. One hour is sometimes considered the maximum for”quick-set" slurry. Setting times may be modified by addition of fillers or chemical agents.
9. The addition of lime or aluminum or ammonium sulphate will accelerate “set". There is a consensus that "break" is controlled by chemical reactions and is not related to "fines". There is some opinion that the setting time of the mix will be increased if the minus #200 exceeds 12%.
10. The laboratory design should be made with the aggregate in the same moisture condition as it probably will be in the field.
11. Curing time may be evaluated by use of a cohesion tester that determines the torque required to rotate a small rubber pad (loaded to 28 psi equivalent to average auto tire pressure) in contact with the slurry. Beginning at the time "of "set", this test is repeated at 15-30 minute intervals until a constant optimum torque is obtained. This time is considered the cure time.
12. Specifications frequently require that loss in a "Wet Track Abrasion Test" (ISSA A1O1) be less than some specified value (usually 75 to 100 grams per square foot). This test, now being standardized by ASTM, measures the resistance of a cured slurry specimen to abrasion, under water, by a rotating piece of rubber hose under a five pound load. High weight losses in the test correlate with high wear rates in the field.
13. It has been alleged that the chemical composition of slag can affect slurry characteristics. THERE HAS BEEN NO DOCUMENTATION TO SUBSTANTIATE THIS.

VII. AGGREGATE QUALITY AND GRADING

1. Uniform (non-varying time-wise) gradings and adequate minus #200 mesh (but not dirty) material are vital to successful slurry. It has peep demonstrated at the Warner Co. plant at Morrisville, Pa, that a typical conventional slag plant can produce slag which makes very good slurry without the use of filler.

2. If current production does not meet minimum quality standards a maximum effort should be made to adjust and/or modify plant equipment. If this does not produce adequate quality adjustments must be obtained by one or more of the following: washing, blending, and additives.
3. A good grading is essential for slurry seal work and is perhaps the most difficult problem for some slag producers. Important factors include:
    a. A high content of fines (#100 & #200 mesh), preferably near the middle of the grading band for the type of slurry being used. Nonplastic slag collector dust has been blended successfully with the slag screenings to increase fines; plastic fines should not be used. Filler can be used with the screenings but may have an adverse effect on setting of the emulsion if used in large amounts.
    b. A smooth grading curve from top to bottom size is needed, preferably in the middle of the specification band for each size. Gap gradings or the presence of oversize particles or agglomerated fines will contribute to segregation and produce torn, unsightly surfaces.
    c. A consistent gradation (time wise) is a vital necessity. The continuous mixer on the slurry machine must be supplied with the same grading from one batch to the next or the operator is forced to try to adjust emulsion and water quantities “on the run”. Such a job is not likely to be satisfactory.

VIII. FACTORS ESPECIALLY IMPORTANT TO GOOD SLURRY

1. Emulsion used must be “compatible” with aggregate used. Individual emulsions "react" (perform) differently with different aggregates. Tests should be performed as a vital element of the mix design. Most emulsion suppliers will provide this service.
2. At <u>all times</u> grading and moisture content of aggregate must be uniform. Stockpiled material should be loaded in a manner which will minimize variation in moisture content and grading (transversely across the stockpile fact). Use of slag direct from processing plant should be prohibited because it is likely to be warm and dry and vary in grading.
3. Optimum "ageing” appears to be to use it after it cools to ambient temperature and before the possibility of cementing action or caking has occurred.
4. Some consider 3-4% of minus #325 mesh important but that it should not exceed 50% of the minus #200 percent. Excess quantity of minus #325 mesh may cause trouble and should be avoided. Research is being conducted to accurately quantify the amount of minus #325 needed.
5. Aggregate must be clean - no agglomerated or plastic fines.
6. Potable water should be used in the mix whenever feasible. Use of pond or river water should be avoided. If any unusual water must be used in the

field it is important that it be used during mix design. Some are of the opinion that hardness should not exceed 9 grams, others have used successfully water with hardness as high as 100.

7. Free water content of mix must be controlled within narrow limits, as determined by laboratory design, usually no more than ±2%.
8. Calcium chloride, or any other chemicals not used in design mix which are used for stockpile dust control, can adversely affect slurry mixes. There are additives for the mix which can compensate for the calcium chloride but they are expensive. If any control chemicals are used during the aggregate processing or handling it is important that the slurry contractor be advised.
9. The two most important aspects of slurry seal to watch and control are non-varying grading in the middle of the specification band for all sizes, and adequate minus #200 and minus #325 mesh material.

IX. PRODUCTION AND PLACEMENT

The mixing and placement of slurry seals is not an "exact science" but there is proven guidelines which should be followed. Experts differ in their opinions of good placement practices or what is the cause of problems. It appears that local conditions have a significant bearing on results and judgments must take these into account. Some conclusions derived from field experiences include:

1. The use of stockpiled material rather than fresh material, especially with slag, is preferred to insure that aggregate is at ambient temperature. It is especially important that slag not be warm (temperature higher than ambient) when it is used; higher temperatures may cause coating problems. "Fresh" slag sometimes is difficult to coat, especially when it is above ambient temperature. Stockpiled material coats easier than fresh slag but lumps may form if stockpiled too long and it is more likely that grading and moisture variation problems will occur. Oversized and/or agglomerated lumps of aggregate can cause trouble in either the mixer or in the freshly laid slurry. To summarize - AS A MINIMUM TIME, be sure slag has cooled to ambient temperature; the optimum time is ageing to a point in time prior to any chance of lumps forming.
2. Uniformity of moisture content and grading is important. Sudden changes from wet to dry batches in the slurry machine can ruin uniformity and quality of the slurry. The use of slag screenings from a fairly large stockpile recovered by loading across the entire face, perpendicular to the stockpile axis, will usually provide minimum moisture and grading variations.
3. Extremely wet aggregates are undesirable, but very dry materials having a high absorption can be equally troublesome. Attempts to use hot, dry slag have resulted in emulsions breaking in the mixer. Very high free moisture

in the aggregate could result in the slurry being too "wet", even without adding any water at the mixer.

4. Compaction or bulking of the aggregate in the slurry machine hopper can have a significant affect on the quality of the slurry produced since all machines except the Madison use a volumetric gate to control aggregate flow. If there is more than 6% water in the hopper bulking will effect the metering. Similarly, compaction of the aggregate as a result of jiggling during movement over considerable distance will result in excessive amounts of aggregate. The Madison machine uses an auger to proportion and move the aggregate to the pugmill.
5. Overmixing of slurry tends to beat air into the mix causing placement and coverage problems. Overmixing, too, may result in a change in color of the slurry. Overmixed slurry should be discarded. When quick-setting emulsion is involved, it is imperative that the overmixed slurry be removed from the mixer as quickly and completely as possible so the mixture will not solidify in place.
6. Mixes have a tendency to "ball" if insufficient water is used in the mixer, but this is only one of several reasons for balling; others are: temperature of aggregate and amount of bitumen and fines.
7. Large variations in aggregate moisture content between that used in the laboratory design and actual field conditions will cause water control problems at the machine.
8. More water will have to be added at the machine as the temperature rises during the day. Cationic emulsions require more added water than anionic.
9. It is not feasible to establish a generally acceptable variance in the percentage of water added at the machine within which satisfactory slurry will be produced. Factors such as condition of the pavement, ambient humidity and temperature, free water in the aggregate, amount of minus #200 and minus #325 mesh material all have a bearing on the amount of water needed and how much it can vary.
10. Slurries made with quick-setting emulsions - either anionic or cationic - can be formulated to break shortly after contact with the aggregate. If break occurs almost instantaneously upon contact with the aggregate, much of the aggregate will remain uncoated, and the mix will not be within specification. If the break is fast enough and if mixing is continued during the brief duration of the break, it is difficult to tell whether the break has occurred. Continued mixing produces slurry in which the coated aggregates are suspended stably in a fluid matrix which consists primarily of water. These "false slurries" should not be applied.
11. There is a consensus that "good" slurry should have the consistency of oatmeal and "roll" in the machine spreader box. It will look “straw like" if there isn't enough emulsion.
12. No slurry should be laid when:

a. There is danger of freezing of the slurry before it is completely cured.
b. When road base or air temperature is 55°F or below and falling. Some slurry contractors are of the opinion it may be applied when temperature of both air and base are 45°F and rising, a few believe the lowest temperature should be 55°P.
c. In a period following a rain, while puddles remain on the surface.
d. Applying a type of slurry that cures by evaporation during periods of high humidity or when rain is expected in a few hours.

13. There is no truth to the allegation that asphalt "floats" to the surface when slag is used; when this occurs it is caused by a faulty mix design or improper adjustments at the machine.
14. If summer heat causes fast evaporation of surface moisture, a film of semi-solid asphalt is formed and seals in moisture, thus extending the curing time and creating a long-lived "tackiness" until it cures.
15. The "white appearance" that sometimes occurs on slurries after placement is more apt to occur when lime is used as filler than when cement is used. While the type of filler used is the basic cause of the white appearance, the frequency and extent of this condition can be affected by the type of emulsifier used, excessive amount of water in the mix which floats the filler to the surface, and slow drying caused by weather conditions or heavy shade. SLAG IS NOT THE CAUSE OF THIS PHENOMENOM.
16. Slag slurry is no more difficult to place by hand than stone or gravel slurry. Trouble stems from "set" characteristics which may be satisfactory for machine placement but too rapid for hand placement.
17. One of the primary causes of aggregate "stripping" is the use of an aggregate and an emulsion with the same electrical charge. Anionic emulsions (- charge) are more sensitive in this respect than cationic (+ charge). Anionic emulsions are very compatible with slag or limestone (+ or neutral charge) and usually give trouble when used with siliceous (- charge) aggregates. Cationic emulsions may cause stripping problems with slag or limestone, but in most instances are compatible. This potential problem should be checked during mix design compatibility test referred to in Section VI.
18. All emulsions of asphalt if exposed to temperature of 32°F or less will be ruined.
19. It is important to maintain continuous quality control of materials being used and checks on the mix design. The "look" of the aggregate or of the slurry cannot be used for control purposes. Experience has shown that many "good-looking" mixes at the beginning do not stand up well.

X. PROJECTS USING SLAG SLURRY

Blast furnace slags have been used in slurry seal work for many years and are, of course, particularly valuable when high skid resistance of the slurry is an important factor. Recommendations of the International Slurry Seal Association have always specifically mentioned slag as one of the aggregates recommended for use in slurry seals.

Applications of slag slurry seals in the early 1960's included airport runways at Maxwell Air Force Base, Grosse Ile Naval Air Station, commercial airports at Akron-Canton and Windsor, Ontario; roads and streets in Florida, Mississippi and Alabama. In more recent years slag projects have included county roads and streets in many states including Michigan, Ohio, Pennsylvania, New York and New Jersey; and airfields such as Pensacola Naval Air Station, the NAFEC at Atlantic City and the Buffalo International Airport.

"Slag slurry" has been used successfully on many projects and some contractors prefer it to all other types of aggregate. Adherence to "good practices" outlined previously is the best way to avoid problems. Data concerning slag slurry jobs which were completed without difficulty and have given good service are summarized in the appendix.

XI. SUMMARY

Slurry seals constitute a valuable and practical maintenance procedure that is growing in use. Adequate equipment, design procedures, specifications and job controls are now available to eliminate most of the early difficulties with misuse and poor construction.

Slag screenings can be used, and have been used, in a variety of highly successful slurry seal applications. Slag is a superior aggregate for this use in all cases where skid resistance of the slurry is important.

Proper attention to the gradation (including uniformity and fines content), compatibility tests with the emulsion to be used, and uniform and reasonable moisture contents will insure successful slag projects with a minimum of field problems.

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9. County Engineer Proves Slag Slurry Seal Effective in Skid-Proofing Slippery Highway Surfaces, NSA 165-4, reprint from Public Works magazine, March 1965.
10. Slag Bituminous Surface Courses, NSA 170-1, section on slurry seals beginning on page 14.

APPENDIX
TYPICAL SLAG SLURRY SEAL APPLICATIONS
DELAWARE RIVER JOINT TOLL BRIDGE COMMISSION
Morrisville, Pa. 19067

In July, 1972 a contract was established between Interstate Asphalt Co., and the Delaware River Bridge Commission to applicate Slurry Seal on bridge deck of the Bushkill Street Toll Bridge and the Northampton Street Free Bridge, located in Easton, Pa.

Two areas were selected:
(1) The toll bridge, spanning the Delaware River, connects Interstate 78 between Pa. and New Jersey. The bridge deck, four lanes, consists of a concrete base with a bituminous con- crete treated surface.
(2) The Free Bridge, spanning the Delaware River, connects downtown Easton, Pa. with downtown Phillipsburg, New Jersey. This bridge deck is consistent of three lanes traveled East and West, with traffic limited to passenger cars and light trucks. The deck also consists of concrete subsequently over-layed with bituminous concrete.

Construction Details

In the case of both bridges, the subject surfaces were prepared by the local maintenance force. The preparation work was comprised of the leveling of a few concentrated de- pressed areas and cleaning. Traffic control was also the responsibility of the local forces.

Work was started on July 20, 1972. One eastbound and one westbound lane on the toll bridge were closed as well as two lanes on the Free Bridge. The following day the balance of both areas were completed.

Based upon observations of the high volume of traffic, followed by subsequent conversation with supervisory personnel, management decided to provide an additional application of Slurry Seal to insure a longer degree of longevity because of the prevailing circum- stances. Furthermore, because of conveniences of the overhead illumination, it was decided to make this additional application during the l8,te evening hour. This operation was brought into focus three days later using the same procedure outlined earlier. The night-time operation proved to be beneficial in that the volume of traffic was considerably reduced, which consequently minimized delays, thereby insuring increased productivity. The weather conditions experience during the daytime application were hot, humid, and 88 degrees; the night-time conditions were warm, balmy, and 81 degrees.

The mineral aggregate was a slag produced by Warner Company, Morrisville, Pa. conforming to the specifications pertinent to Pennsylvania Department of Highways Form 408, Section 482, Type II. Raw gradations stockpiled on the job site were as follows:

Sieve No.	% Passing	Spec	Sieve No.	% Passing	Spec
200	7.1	5-15	16	59.2	45-80
100	14.7	8-25	8	83.5	70-100
50	24.8	15-40	4	99.9	90-100
30	38.5	25-60	3/8	100	100

The Asphalt Emulsion was classified as E-8c (CSS1H) conforming to the requirements listed in Pennsylvania Department of Transportation Bulletin 25, and produced by Windsor Service Company, Reading, Pa.

NAVY NAFEC BASE, Pamona, N. J.
for Federal Aviation Administration

Materials Used

Coarse Aggregate - Blast Furnace Slag Screenings
Mineral Filler - Portland Cement
Emulsion - Type CSS-1H from West Bank Oil, Inc., Cherry Hill, New Jersey

Mechanical Analysis

Sieve Sizes	Blast Furnace Slag Screenings % Passing	Portland Cement % Passing	Combined Gradations % Passing	Specifications
3/8"	100	-	100	100
4	99.3	-	99.3	85-100
8	82.1	-	82.3	65-90
16	57.0	-	56.4	45-75
30	38.1	-	38.7	30-55
50	25.2	-	25.9	18-35
100	14.7	100	15.3	10-21
200	9.0	97.7	9.8	5-15
325	6.3	92.0		

Apparent Specific Gravity   Slag: 2.860   Cement: 3.150

Asphalt Emulsion

Type CSS-1H Tank 76 - West Bank Oil, Inc., Paulsboro, New Jersey,

Asphalt Content (% by WT.)	62.5
Water (% by WT.)	37.5
Viscosity S.F. @77°F	23
Specific Gravity @60°F	1.014
Residue from Distillation	
Penetration @77°F	69
Solubility CC	99.9%
Ash (% by WT.)	0.1%
Particle Charge Positive	

Mix Design

Blast Furnace Slag Screenings	99%
Portland Cement	1%
Water	8-10% of aggregate weight
Emulsions (As received)	16.5-17% of aggregate weight

The mineral dolomitic limestone filler used in this instance was manufactured by the New Jersey Zinc Company, Friedensville, Pa., with the following gradations:

Sieve No.	% Passing	Sieve No.	% Passing
200	82.5	50	99.9
100	97.5	30	100

The water used was supplied by the Bridge Commission obtained from Fire hydrants with water supplied by the Suburban Water Company.

The design mix was as follows:

Aggregate	70.35%	Emulsion	18.40%
Water	10.00%	Mineral Filler	1.25%

A Young, Model FB800 and a Madison, Model CM 12 slurry machine were used.

<u>Job Performance</u>

The results of the finished product were very satisfactory. Curing time attributed to either the day/night applications did not exceed eight hours. The yield of the double application was 31.1 pounds per square yard.

Periodic inspections of the sites have been made. The following is an excerpt of a letter dated January 14, 1974, depicting the findings during the most recent formal inspection by the Engineering Department of the Delaware River Joint Toll Bridge Commission.

"The Bridge deck on the Bushkill Street Toll Bridge was inspected the first week in January. It is apparent that the Slurry Seal has worn away in the wheel "tracks" of the outside lanes which are of course predominately truck traffic. These worn areas are not continuous the full length of the bridge, indicating probably another year's wear before the entire wheel lanes are worn off. The inside lanes, at this point in time, do not reveal wearing to the extent that the original deck pavement shown thru. The same situation exists on the Northampton Street Free Bridge except the wear in the wheel "Tracks" is the result of automobile traffic and not trucks."

An informal inspection of both sites was made February 18, 1975. The condition was essentially the same as described above. The surface was still serviceable and skid resistance appeared to be high.

Tabulated below are data supplied by the Commission of the average daily traffic count for the bridges, (approximately 30% of the traffic figures are tractor-trailer type, and it is the custom (and in some instances required) for truckers to use the outside lanes).

AVERAGE DAILY TRAFFIC COUNT-EASTON-PHILLIPSBURG TOLL BRIDGE

July'72	34,531	**Oct.**	33,113	**Jan.'73**	27,998	**Apr.**	33,086	**July**	36,132	**Oct.**	32,965
Aug.	36,161	**Nov.**	31,421	**Feb.**	28,878	**May**	34,098	**Aug.**	37,509		
Sept.	33,237	**Dec.**	29,167	**Mar.**	30,788	**June**	34,943	**Sept.**	32,834		

AVERAGE DAILY TRAFFIC COUNT-NORTHAMPTON STREET FREE BRIDGE

July'72	22,930	**Oct.**	21,000	**Jan.'73**	21,726	**Apr.**	23,924	**July**	24,064	**Oct.**	23,974
Aug.	22,956	**Nov.**	21,645	**Feb.**	22,515	**May**	23,656	**Aug.**	24,246		
Sept.	21,953	**Dec.**	22,141	**Mar.**	23,951	**June**	25,175	**Sept.**	24,217		

Both bridge surfaces were informally inspected Feb. 19, 1975. The surfaces were still in excellent condition and a highway official indicated that a slurry resurfacing would not be required until 1976. There were a few "spots" where slurry had worn appreciably but the overall skid resistance appeared to be excellent. There were very few reflection cracks and the general physical condition of the surface was water repellant and good.