DESIGN & INSPECTION MANUAL

For Slurry Surfacing Systems

800 Roosevelt Rd, C-312, Glen Ellyn, IL 60137
Slurry.org | 630.942.6577

2nd Edition

ISSA Design and Inspection Manual for Slurry Surfacing Systems

2021

NOTICE

The ISSA Design and Inspection Manual for Slurry Surfacing Systems is intended as a guide to agencies and contractors. It is not intended or recommended that the information provided be used in its entirety as verbatim specifications. ISSA assumes no liability for any slurry systems applications applied pursuant to the information in this Manual.

International Slurry Surfacing Association
800 Roosevelt Road, Building C-312
Glen Ellyn, IL 60137
(630) 942-6577
www.slurry.org

ACKNOWLEDGEMENTS

Decades of slurry surfacing technology development by countless numbers of passionate ISSA members and their companies are responsible for the state of today's best practices for our segment of this industry. Articulating those practices in this Manual has come about by a group of individuals with a commitment to excellence, passion for the pavement preservation technology of slurry surfacing systems, and a willingness to commit untold numbers of hours to bringing this edition to fruition. It is only through the dedication of those individuals and the ISSA member companies that employ them, along with the support of the ISSA Board of Directors, that this resource is available to the pavement preservation industry.

Acknowledgements for the technical content of the Manual go to:

Debbi Deep, Ingevity Corporation

Tim Harrawood, Vance Brothers

Chuck Ingram, Slurry Pavers

Bob Jerman, ISSA

Larry Tomkins, Ergon

Acknowledgements for administrative support and formatting go to:

Robert Betsold, All States Materials Group

Ali Mostardo, CM Services

Anne Walhout, CM Services

NOTICE

All content in this Manual represents an opinion of a member of the team acknowledged above and does not constitute an endorsement, recommendation, or legal advice. ISSA assumes no liability for any slurry systems applications applied pursuant to the information in this Manual.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

ICON KEY

Indicates a **Designer's Note**

Indicates an **Inspector's Note**

INTERNATIONAL SLURRY SURFACING ASSOCIATION (ISSA) DESIGN AND INSPECTION MANUAL

I. INTRODUCTION

A. Foreword

Although this manual cannot cover all information that may be applicable in every part of the world, we have attempted to incorporate current best practices for design and inspection so as to provide the information most important to successful slurry surfacing system construction.

B. Background[1]

Slurry surfacing was first developed in Europe, where it is generically known as micro-asphalt concrete. In the early 1930s, a coating consisting of a mixture of very fine aggregate, emulsified asphalt, and water was placed on a road in Germany. This new and promising technique in maintaining road surfaces marked the beginning of slurry surfacing development.

Worldwide experimentation continued, but it was not until the 1960s, with the introduction of improved emulsifiers, continuous flow machines, and set control additives that real interest was shown in slurry surfacing systems for a wide variety of applications. In the mid-1970s, Screg Route, a French company, designed Seal-Gum, a micro-asphalt concrete that was subsequently improved by the German firm Raschig and marketed in the United States under the trade name "Ralumac®".

Figure 1 - Slurry Surfacing System Project

Since the introduction of Ralumac in 1980, micro surfacing has been used by many state DOTs and local agencies in the United States on moderate to high volume roads. In fact, micro surfacing applications have conclusively demonstrated that the treatment can be a highly successful preservation and maintenance technique. However, despite this success, it is crucial that managers and engineers fully understand micro surfacing's limitations, performance

[1] See 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.

variables, and materials/mixture requirements to ensure that the treatment is used only when appropriate.

Continuing improvement of mixing methods, emulsified asphalt and machinery have made slurry surfacing systems today's choice in providing highly durable, cost effective surface treatments. Slurry surfacing systems are now used extensively throughout the world.

Figure 2 - Ralumac Micro Surfacing – King Rama IX Bridge, Bangkok

C. Purpose of the Manual

The purpose of this manual is to provide practical information to assist in the project design and construction inspection of slurry surfacing system (slurry seal and micro surfacing) projects. The ISSA's Board of Directors authorized the manual's development to provide an educational tool that could be used by persons possessing limited familiarity with slurry surfacing system methods.

The designer and inspector have an essential and vital role during the construction of every slurry surfacing system project. The designer's job may include determining proper site selection and material requirements, plan development, project cost estimation, and project scheduling. The inspector's job is to ensure that the slurry surfacing system design is applied according to the project plans and specifications.

The contract between the owner and contractor includes plans and specifications that must be followed during construction and met by the finished product. The fulfillment of these requirements often determines the quality of the finished slurry surfacing system. It is the inspector's responsibility to identify deviations from the specifications and to bring them to the attention of the contractor. It is important to remember that good inspection practice encourages the prompt resolution of problems, preferably as they occur.

This manual is designed to provide the basic knowledge needed to understand and evaluate slurry surfacing systems and construction as well as enough background knowledge to assist the designer and inspector in making good decisions. It also provides guidance relative to the appropriate materials necessary for various applications of slurry surfacing systems, and the analytical procedures to assure the desired service life. The manual will detail areas of importance to watch for in the field. If additional information is desired, much of the content contained here is addressed in greater detail in various ISSA Technical Bulletins and Guidelines which are available at the ISSA website (https://www.slurry.org/page/guidelines). In addition, Web Based Training Modules on slurry surfacing systems are available at (https://www.slurry.org/page/indtrainingcourses).

A manual alone is insufficient and should be used in conjunction with other learning tools, such as classroom, on-the-job, or in-the-lab training. The job site is an ideal classroom to observe, ask questions, and obtain answers. Highly qualified, quality-oriented ISSA professionals can provide as much detailed, technical information as an inspector may request. Formal training opportunities are available through the ISSA Slurry Systems Workshop and joint ISSA/agency training classes. Basic specification guidelines can be found in ISSA publications "A105: Recommended Performance Guideline for Emulsified Asphalt Slurry Seal", "A115: Recommended Performance Guideline for Polymer-Modified Emulsified Asphalt Slurry Seal (Provisional)", and "A143: Recommended Performance Guideline for Micro Surfacing" (See Appendices I, J, and K). Further technical information on design and testing can be found in the Design Technical Bulletins available as free downloads from ISSA at www.slurry.org.

II. SLURRY SURFACING SYSTEMS

A. Terminology

The generic term slurry surfacing systems is used throughout this manual for the following forms of pavement preservation treatments: slurry seal, polymer-modified slurry seal, and micro surfacing. Today, the industry distinguishes the three categories as follows:

Slurry Seal - A mixture of aggregate, emulsified asphalt, water, and additives properly proportioned, mixed and spread over a properly prepared surface. Slurry seal is applied in a mono-layer. A mono-layer is considered one stone thickness (based on the largest stone in the gradation) spread on the pavement surface.

Polymer-Modified Slurry Seal - A slurry seal designed with an emulsified asphalt that has been modified with a polymer.

Designer's Note: Modifying emulsified asphalt may improve the bond between the asphalt and the aggregate and may improve durability and toughness of the slurry surfacing system. One example of increased durability and toughness may be reduction of power steering marks.

Micro Surfacing - A mixture of cationic polymer-modified emulsified asphalt, 100% crushed aggregate, water and other additives, properly proportioned and spread over a prepared surface. The special purpose polymers and additives used in micro surfacing allow multiple stone thickness applications for projects such as rut filling and minor highway leveling/reprofiling.

B. Benefits

Slurry surfacing systems provide life extending benefits as well as surface condition improvements (to International Roughness Index (IRI), overall Pavement Condition Index (PCI), permeability, friction, etc.) and are considered a cost-effective treatment strategy, preserving past investments in existing highways, roads and streets.

1. **Extending Pavement Service Life**
   Although the application of a slurry surfacing system treatment does not increase the structural capacity of the pavement, it does preserve the integrity of the structure. This is primarily achieved by reducing the environmental damage that would otherwise deteriorate the pavement from the top down.

   The integrity of the pavement structure should be determined prior to selecting a slurry surfacing system treatment. This can be accomplished by a detailed pavement distress analysis by an experienced pavement engineer. Given a good pavement structure, proper timing of the application and selection of a suitable slurry surfacing system, a well-constructed treatment can substantially extend pavement service life.

2. **Decreasing Pavement Permeability**
   Permeability exists in asphalt pavements from the time of initial construction through the service life of the pavement. The aging process is closely linked to the crude source of the asphalt, the environment, and interconnected air voids near the pavement surface through which oxygen and moisture can infiltrate. Water entering through the asphalt concrete surface carries dissolved oxygen and trace chemicals which contribute to the oxidation of the asphalt. As this process progresses, the asphalt binder becomes brittle. Oxidation leads to weathering, raveling, and cracking of the pavement surface. By placing a protective layer on the existing surface, permeability is reduced. Consequently, weathering, raveling, and age-accelerated surface cracking are less likely to occur.

3. **Improving Surface Friction**
   Aggregate particle shape and gradation, pavement finishing techniques and pavement wear contribute to pavement surface texture. Research indicates that about 14 percent of all crashes occur in wet weather, and that 70 percent of these crashes are preventable with improved pavement texture/friction. Inadequate friction contributes to accidents in dry weather as well, especially in work zones and intersections where unusual traffic movements and braking action are common.

   Slurry surfacing systems with proper macro texture provide good surface friction when 100% crushed and durable aggregates are used and application rates and construction practices are appropriate.

   <u>Designer's Note:</u> In most cases, a properly designed and installed Type III aggregate gradation will provide the highest system friction values.

4. **Addressing Moderate Bleeding/Flushing**
   Application of a micro surfacing treatment may successfully correct moderate flushing and reduce bleeding in an existing pavement.

   <u>Designer's Note:</u> Generally, when micro surfacing (not slurry seal) is the chosen slurry surfacing application, two layers are needed to substantially reduce the probability that the excess asphalt in the existing layer causes flushing in the

micro surfacing. In addition, the micro surfacing design should consider the flushing condition and the residual asphalt content should be reduced accordingly. The severity of the problem will dictate whether micro surfacing is the appropriate solution. If so, these repairs should be addressed in cooler application conditions. For assistance evaluating individual situations, consult your local ISSA member/contractor.

C. Application

Slurry surfacing systems are mixed in specially designed application equipment which includes compact, truck-mounted, trailer-mounted or continuous-run pavers. Each type of placement machine carries a quantity of unmixed materials which are blended together in a continuous flow pugmill. The component materials are measured volumetrically and fed into the pugmill based on the mix design.

Designer's Note: The truck-mounted paver is generally used on smaller sized projects and in locations where maneuverability is needed. A trailer-mounted paver is suitable equipment for medium to large sized projects. A continuous-run paver is ideal for large jobs where high production is needed.

The materials, including aggregate, mineral filler, emulsified asphalt (often polymer-modified), additives, and water are mixed in the pugmill. From the pugmill the mixture flows into the spreader box at the rear of the application equipment. The mixture is then applied to the pavement surface by the spreader box. The application equipment operator can adjust the amount of water in order to maintain proper mixture consistency. If necessary, additive may be used to control the mix time and setting characteristics of the mixture, impacting return to traffic time. Compaction/rolling is not normally needed or applied. Changes in temperature, humidity, and texture of the existing surface can lead to a change in the amount of water and/or additive required.

D. Project Selection

Slurry surfacing system treatments may not be effective if applied reactively to roads in poor condition instead of proactively to roads still in good condition. The correct approach to pavement preservation is to "place the right treatment on the right road at the right time" as seen in Figure 3. Traditional approaches waited until deficiencies became evident even to the untrained observer, at which time the owner was trapped into the unfavorable choice of either applying major rehabilitation or complete reconstruction. The correct approach of effectively using slurry surfacing systems is to think in terms of preservation and address minor deficiencies early (before serious, irreversible underlying structural damage occurs). In this way, pavement life can be substantially extended at comparatively low cost. More information on proper site selection for slurry surfacing systems can be found at https://roadresource.org/.

Figure 3 - Application of a Slurry Surfacing System Treatment

<u>Designer's Note:</u> Slurry surfacing system treatments will initially fill and seal most cracks; however, the treatments may not prevent cracks from reappearing, sometimes relatively quickly. Even if the crack returns, the distress is typically not as severe as it was prior to treatment. Additional reflective crack control can be achieved by combining slurry surfacing with other treatments, such as crack, chip and scrub sealing.

III. MATERIALS

A. Aggregate

Aggregates are composed of many different types of minerals. While many are excellent for slurry surfacing system use, some are not. Aggregates must be clean to ensure that the asphalt bonds to the aggregate particles and durable to ensure long-term performance. Aggregate size and physical property requirements will vary based on the gradation and type of slurry surfacing system (standard, modified, or micro surfacing) project specified.

Slurry surfacing systems require quality crushed aggregate such as granite, slag, limestone, or chat. Other high-quality aggregate, or combinations thereof, should be used. To assure the material is 100 percent crushed, the parent aggregate must be larger than the largest stone in the gradation. Quality aggregate must meet specified requirements for gradation, particle shape, and cleanliness or sand equivalent value.

The following laboratory tests are used to qualify the aggregate for suitability on the specific slurry surfacing system project. Other aggregate testing may include moisture effect on unit weight (bulking effect). This test is listed in the section on mix design and its importance is discussed in Section III.C.1, page 19, Moisture Present in the Aggregate Stockpile. Most importantly, the aggregate must be mixed with the emulsified asphalt and additives to determine compatibility before acceptance for use.

The aggregate's key characteristics for suitable incorporation into a slurry surfacing system are:

1. Aggregate Gradation/Particle Size Distribution

In most cases the aggregate from a single source will not vary substantially during a project. Aggregate variation may be caused by different phases of the project occurring over a long period of time, location changes within the quarry or pit where aggregates are extracted, or gradation fluctuations.

Aggregate gradation directly affects the amount of emulsified asphalt required for a slurry surfacing system. Variations in aggregate gradation, even within the allowable specified ranges, will change the total aggregate surface area to be coated by emulsified asphalt. Thus, consistency is important when selecting an aggregate for a project.

<u>Inspector's Note:</u> The inspector should be alert for unusual changes brought about by gradation fluctuation (especially on the fine aggregate sizes) which may cause enough variation in the gradation to invalidate the existing mix design.

By design, slurry seals are to be applied in a layer equal to the largest stone in the gradation. Slurry seal applied at less than, or in excess of, the recommended application rate, or in multiple layers, may create an unstable treatment leading to raveling, flushing, rutting, or washboarding.

<u>Designer's Note:</u> For aggregate on the coarse side of the gradation specification, application rates should be higher. Otherwise, the largest aggregate particles will not adequately embed in the slurry surfacing mixture. Insufficient embedment may cause drag marks when larger stones are caught by the strike-off rubber. Raveling may result from insufficient embedment, as well. Conversely, for aggregate on the fine side of the gradation specification, application rates should be lower to avoid flushing of the surface.

ISSA specifies three standard gradations, each with a designated use for the surface condition to be addressed.

ISSA Type I: This aggregate gradation is used to fill surface voids, address moderate surface distresses, and provide protection from the elements. Although not a substitute for crack sealing, the fineness of this mixture provides maximum crack penetration. It is frequently used on airfields, parking lots, and residential streets where a tighter, finer surface texture is desired.

ISSA Type II: This aggregate gradation is used to seal/fill surface voids, address more severe surface distresses, and provide a durable wearing surface. It is the most common gradation used in slurry surfacing systems. It is often used on pavements to correct distresses caused by weathering and raveling while producing an adequate wearing surface for low, medium and heavy traffic volumes. This gradation is commonly used on airfields, parking lots, municipal streets, county roads and highways.

ISSA Type III: This aggregate gradation, which is the coarsest of the three ISSA types, gives maximum coefficient of friction and an improved durability due to the depth of the application, as the larger aggregate size increases the thickness of the mat placed. It is best suited to higher-traffic pavements such as expressways, major highways and arterials. When used in micro surfacing, this gradation is ideal for rut filling and re-establishing profiles with minor surface irregularities.

Sieve Sizes	Type I Percent Passing	Type II Percent Passing	Type III Percent Passing
3/8" (9.5 mm)	100	100	100
No. 4 (4.75 mm)	100	90-100	70-90
No. 8 (2.36 mm)	90-100	65-90	45-70
No. 16 (1.18 mm)	65-90	45-70	28-50
No. 30 (600 µm)	40-65	30-50	19-34
No. 50 (300 µm)	25-42	18-30	12-25
No. 100 (150 µm)	15-30	10-21	7-18
No. 200 (75 µm)	10-20	5-15	5-15

Table 1 - Standard ISSA Aggregate Gradations

Sieve Analysis Tests – [American Society for Testing and Materials (ASTM) C117 or American Association of State Highway and Transportation Officials (AASHTO) T11: Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing and ASTM C 136 or AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregates]
This test is used to determine the gradation of materials proposed for use as aggregate. The results are used to determine compliance with the specified particle size distribution and to provide data for quality control of the supply of aggregate to the project

2. **Particle Shape**
100% crushed aggregate is required, allowing the fractured faces to interlock and resist movement. Slurry surfacing system mixtures with a higher percentage of flat and elongated particles (3:1 ratio) may exhibit lower shear stiffness, which could be problematic, especially for rut filling applications. If this test is required, refer to local specifications for methods and percentage maximums.

3. **Cleanliness or Presence of Deleterious Materials**
Aggregates must be relatively clean when used in slurry surfacing systems. Vegetation, clay lumps and excess dust or dirt affect performance by preventing proper asphalt-aggregate bonding. Micro surfacing aggregates must be cleaner than those used in conventional slurry systems.

Sand Equivalent Test - (ASTM D2419 or AASHTO T176: Sand Equivalent Value of Soils and Fine Aggregate)
This test assigns an empirical value to the relative amount of claylike material present in the test specimen. It evaluates the cleanliness of the aggregate, measuring the amount of expansive clays or organic materials.

4. **Toughness and Abrasion Resistance**
Aggregates undergo substantial wear and tear. In general, they should be hard enough to resist crushing, degradation and polishing during the application process and throughout the life cycle of the pavement. Aggregates not adequately resistant to abrasion and polishing may cause a loss of skid resistance.

Abrasion Resistance Test - (ASTM C131 or AASHTO T96: Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine)
This test indicates the hardness or toughness of the aggregate. It measures aggregate degradation of the parent rock under wear conditions. The results do not automatically permit valid comparisons to be made between sources distinctly different in origin, composition, or structure. Assign specification limits with extreme care in consideration of available aggregate types and their performance history in specific end uses.

5. **Durability and Soundness**
   Aggregates that are durable (resistant to weathering) are less likely to degrade in the field and cause premature pavement distress. The soundness test determines an aggregate's resistance to degradation by weathering, specifically by freeze-thaw cycles.

Soundness of Aggregates - (ASTM C88 or AASHTO T104: Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate)
This test determines the aggregate's resistance to weathering, giving an indication of its freeze/thaw characteristics.

B. Emulsified Asphalt

Asphalt viscosity must be reduced before it can be pumped, mixed with aggregate, or sprayed through nozzles. One way to accomplish this is to co-mill the asphalt with a solution of emulsifier, water, and acid/caustic. In the emulsification process, hot asphalt is mechanically sheared into very small particles (~5-10 microns), stabilized by the emulsifier and dispersed throughout the water phase. The emulsifier keeps the asphalt particles separated from one another and suspended in the water which allows the asphalt to be used at ambient temperatures. After the emulsified asphalt is mixed with the aggregate and placed on the pavement surface the emulsified asphalt breaks, expelling the water and leaving the asphalt residue behind to bind the mixture. The resulting application bonds to the existing pavement surface, sealing and waterproofing the layer upon which it is placed.

1. **Manufacturing Process**
   An emulsified asphalt is a mixture of water, emulsifier (surfactant) and asphalt. To produce an emulsified asphalt, the asphalt and emulsifier solution are pumped at proper temperature into a colloid mill. The mill contains a high-speed rotor that turns at a very close tolerance to a stator. As a result, the asphalt is sheared into micron-sized particles, each of which is stabilized by emulsifier molecules.

   Emulsifiers are used to stabilize the asphalt particles to keep them from coalescing during storage and transportation. The stabilized asphalt particles have an electrical charge, which originates from the emulsifier molecule. Because all the particles have the same charge, they repel each other and remain suspended in the water phase.

   These electrical charges are a characteristic of the emulsifier chosen. Cationic and anionic emulsified asphalts are the two types most commonly used, with cationic being the primary type for slurry surfacing systems. Cationic emulsifiers give the emulsified asphalt a positive charge, while anionic emulsifiers give the emulsified asphalt a negative charge. Cationic emulsified asphalts are acidic (low pH) and anionic emulsified asphalts are alkaline (high pH).

Emulsified asphalts used in slurry surfacing systems are stored and used at ambient or warm temperatures, brown in color, and exhibit a low viscosity. For emulsified asphalt used in high performance slurry surfacing systems, the particle size significantly impacts system performance characteristics such as curing and return-to-traffic.

Emulsified asphalt used in slurry surfacing systems contains 60-65% asphalt and sufficient emulsifier, polymer (when required), acid (or caustic) to adjust pH, and water to make up 100 percent. Emulsified asphalt is brown in color during storage. When mixed with the aggregate the asphalt particles form a film on the aggregate surface and change in color from brown to black ("break"). This is known as coalescence.

2. Handling and Storage of Emulsified Asphalts

Emulsified asphalt can be sensitive to shear caused by excessive pumping or agitation and since it contains water, should be protected from freezing. Adverse conditions can result in agglomeration of the fine, micron-sized asphalt particles forming "shot" or skin on the surface or completely broken emulsified asphalt. Excessive amounts may cause streaks in the finished mat; however, careful screening and disposal of small quantities of "shot" or skin, before blending with the aggregate, may result in emulsified asphalt that is acceptable for use.

A thin, white layer may appear on the top or bottom of latex-modified emulsified asphalt, especially if it is stored for an extended period of time without circulation or agitation. This phenomenon is not uncommon and the emulsified asphalt can be used without issue after gentle agitation.

Transporting emulsified asphalt in tankers previously used for hauling other dissimilarly charged emulsified asphalt products may result in cross-contamination. Destabilization may result if the transport tanker is not property cleaned prior to loading. This is not a common problem as most emulsified asphalt manufacturers have dedicated tankers that haul slurry surfacing systems products only.

3. Emulsified Asphalt Testing

Precautions should be taken to obtain samples that reflect the true nature of the emulsified asphalt used in the field. Improper sampling techniques could impact results of emulsified asphalt testing. Sampling should be completed according to ASTM D140, Standard Practice for Sampling Asphalt Materials. Complete tests on emulsified asphalt within 14 days of the sample date and tests on the residue properties within 30 days of the sample date.

Inspector's Note: The best place to sample emulsified asphalts in the field is from the sample valve of the tanker trailer or the storage tank.

Figure 4 - Sample Valve Location

Samples should be properly labeled with the following information:

- Material type
- Contract Number
- Date sampled
- Sampler
- Where the sample was taken from

A minimum of 1-gallon of material should be run through the sample valve and discarded prior to collection of the sample. All samples should be collected in wide mouth jars, bottles made of plastic or wide-mouth plastic lined cans with lined, screw caps.

Figure 5 - Emulsified Asphalt Sample Container Options

Containers should be filled slowly to avoid entraining air and completely to minimize skin or condensation formation. Samples should not be exposed to direct sunlight for long periods of time or allowed to freeze. Those that have not been tested within 30 days of sampling should be discarded as test results may not be valid.

Tests run on the emulsified asphalt may include:

- **Residual Asphalt Content – (ASTM D6997 or AASHTO T59: Standard Test Method for Distillation of Emulsified Asphalt)**

This test is used to determine the percentage of solids in the emulsified asphalt. The solids include those from asphalt, emulsifier and polymer (if present in the formulation). For emulsified asphalt containing polymer, the maximum distillation temperature should be 350˚F, maintained for 20 minutes.

- **Penetration Test on Residue – (ASTM D5 or AASHTO T49: Standard Test Method for Penetration of Bituminous Materials)**
  This test measures the hardness of the emulsified asphalt residue.
- **Viscosity Test – (ASTM D7496 or AASHTO T72: Standard Test Method for Viscosity of Emulsified Asphalt by Saybolt Furol Viscometer)**
  This test provides a measure of the resistance of the emulsified asphalt to flow at 77˚F.
- **Particle Charge Test – (ASTM D7402 or AASHTO T59: Standard Practice for Identifying Cationic Emulsified Asphalts)**
  This practice is used to identify the emulsified asphalt as cationic.
- **Sieve Test – (ASTM D6933 or AASHTO T59: Standard Test Method for Oversized Particles in Emulsified Asphalts [Sieve Test])**
  This test method measures the percentage of asphalt or other discreet solids retained on an 850-μm mesh sieve.
- **24-hour and/or 5-day Settlement – (ASTM D6930 or AASHTO T59: Standard Test Method for Settlement and Storage Stability of Emulsified Asphalts)**
  These tests quantify the settling characteristics of the emulsified asphalt over time. The requirements may be waived if successful application of the material has been achieved in the field.
- **Softening Point Test – (ASTM D36 or AASHTO T53: Standard Test Method for Softening Point of Bitumen [Ring and Ball Apparatus])**
  This test is indicative of the tendency of the material to flow at elevated temperatures encountered in service.
- **Elastic Recovery – (ASTM D6084 or AASHTO T301: Standard Test Method for Elastic Recovery of Bituminous Materials by Ductilometer)**
  This test is useful in confirming that a material has been added to the asphalt to provide a significant elastomeric characteristic.

C. Water

Water is an important part of a stable mixture and the percentage in the total mix significantly impacts the consistency of slurry surfacing systems. Water to fill the tank of the application equipment may be obtained from any source that is potable (water suitable for drinking). Brackish water, salt water, or water containing silt should be avoided.

<u>Inspector's Note:</u> When field conditions require, fogging with water ahead of the spreader box wets the pavement surface reducing surface tension and temperature and promoting a stronger bond. The fog spray application rate depends on the pavement's temperature, texture, existing surface moisture content and the environmental humidity. *(More information on pavement pre-wetting appears in Section VI.E.2, page 47, Pavement Pre-Wetting.)*

Water is introduced in three ways.

1. **Moisture Present in the Aggregate Stockpile**
   Moisture changes in the aggregate stockpile have a subsequent effect upon the calibration settings of the application equipment. The quantitative effects of moisture content on the unit weight of the aggregate (bulking effect) should be evaluated during the mix design process. During production, if the stockpile moisture changes, the bulking effect may be needed to adjust the mass rate at which the aggregate is delivered to the pugmill.

2. **Water Introduced to the Pugmill During the Mixing Process**
   For most combinations of aggregate and emulsified asphalt, stable slurry surfacing systems can be designed within a reasonable range of added water. Too little water leads to mixes that are too stiff to spread, and too much water leads to segregation of the mix. Segregation is evidenced by settling of the aggregate and floating of the asphalt and fines. Control of added water is very important and the least amount needed to achieve proper mix consistency should be used.

3. **Water in the Emulsified Asphalt**
   Emulsified asphalt also adds water to slurry surfacing systems, since the emulsified asphalt is approximately 35-40 percent water.

D. Additives

Additives are included in slurry surfacing system formulations to adjust the workability of the mixture and/or to modify the setting and curing characteristics. They may be mineral fillers or liquid additives. Improper use of additives may impact the performance properties of slurry surfacing systems. Therefore, their effect on system performance must be evaluated during the mix design process.

1. **Mineral Fillers**
   Mineral fillers are typically used to improve mixture consistency and/or adjust mixture breaking and curing properties. Portland cement, hydrated lime, limestone dust, fly ash, or other approved fillers meeting the requirements of ASTM D242, Standard Specification for Mineral Filler for Asphalt Mixtures, shall be used, if required by the mix design. Typical use levels are 0 - 3 percent and may be calculated as part of the aggregate gradation. On some occasions, mineral filler may be used solely to improve the gradation of the aggregate.

2. **Liquid Additives**
   Liquid aluminum sulfate and amine-based chemistries are the most commonly used liquid additives. These materials are added at varying rates, depending on the concentration of the additive and the delivery system of the application equipment. These additives perform as either break retarders or set accelerators.

Inspector's Note: The percent of mineral filler or set control additive can change during daily operations within the design limits recommended in the Job Mix Formula (JMF).

IV. SLURRY SURFACING MIXTURE CONCEPTS

Slurry surfacing mixtures may contain some combination of emulsified asphalt, aggregate, mineral filler, water, and additives.

> <u>*Designer's Note:*</u> *Micro surfacing systems require higher quality aggregate and the emulsified asphalt is always polymer-modified. They are required to meet higher performance standards during the mix design evaluation. Slurry seal performance is less sensitive to lower quality aggregate and the emulsified asphalt may, or may not, be polymer-modified.*

Although not widely used, slow-set slurry systems break and set mainly by the evaporation of water. Quick-set slurry seal and micro surfacing systems break and set primarily because of electrical charge interactions between the aggregate and the emulsified asphalt. The speed at which the emulsified asphalt breaks is strongly influenced by the charge characteristics of the aggregate. Most aggregates are negatively charged; however, limestone is an exception, since it is predominantly positively charged. Some aggregates have surface charges that are so high (for example, some freshly crushed aggregates) that suitable mix time is difficult to obtain. Others have such low surface charge that the result may be delayed setting and curing. What is most important, however, is that experienced design labs understand the slurry surfacing system formulation techniques necessary to address these issues for a broad range of aggregates.

Most slurry surfacing systems use cationic emulsified asphalt. When mixed with the aggregate, the positively charged emulsifier molecule chemically bonds to the negative sites on the aggregate surface. This is also true of limestone aggregates that, while predominantly positively charged, also contain negative sites. This charge interaction destabilizes the asphalt droplets which then coalesce into an asphalt film that forms a water resistant, adhesive bond to the aggregate. The addition of alkaline mineral fillers, such as hydrated lime or Portland cement, also contribute to the chemical break through a shift in emulsified asphalt pH. One factor in the long-term performance of slurry seal and micro surfacing mixtures is the strength and water resistance of the asphalt-aggregate bond.

The mixing and breaking characteristics of slurry surfacing systems may be controlled using chemical additives. These chemicals are normally added into the water as it is introduced into the pugmill during the mixing process. By increasing the stability of the system, they allow for prolonged workability. Depending on job environmental conditions, properly designed quick-set slurry and micro surfacing systems can accept slow-moving, straight-rolling traffic within one hour after placement. Assuming proper site selection for these treatments, the life extension averages between five and seven years for relatively high traffic roads and may be considerably longer for those with low to moderate traffic.

> <u>*Inspector's Note:*</u> *Ambient, material, and pavement temperatures are important variables in the setting and curing of slurry surfacing mixtures. The impact of temperature on the system may vary greatly. Cooler temperatures slow the break and set of the systems, while warmer temperatures drive the chemical interaction between components and accelerate the break and set.*

Recommended temperatures for application of slurry seal and micro surfacing systems are reported in "Weather Limitations" of ISSA A105 "Recommended Performance Guideline for Emulsified Asphalt

Slurry Seal", ISSA A115 "Recommended Performance Guideline for Polymer-Modified Emulsified Asphalt Slurry Seal – Provisional" and ISSA A143 "Recommended Performance Guideline for Micro Surfacing" which are found in the appendices.

A. Slurry Surfacing Mix Design

A mix design is a laboratory model of expected slurry surfacing performance based on a specified mixture of job materials under specific application conditions. It is imperative that the materials used in the design are representative of the materials to be used on the project and that no material substitution is permitted unless first verified in the lab. The testing lab performing the mix design should have a knowledgeable staff experienced in performing the required tests. ISSA can provide a list of laboratories experienced in slurry seal and micro surfacing design.

Designer's Note: It is recommended that the mix design be performed during the same paving season as the project is applied. In all cases, the mix design should not be older than 12 months to receive authorization for use on the project.

1. Importance of Design

The job specifications, as well as materials proposed for the project, should be supplied to the testing lab well in advance of the start date. Material specifications must be met before the laboratory can proceed with system tests. The lab first establishes a mix formulation with sufficient mix time, then short and long-term performance tests are run. These tests are used to estimate return-to-traffic time as well as to establish the minimum and maximum residual asphalt content required for long-term performance of the mixture. The percentage of each individual material required shall be shown in the laboratory report. Based on field conditions, adjustments within the specific ranges of the mix design tolerances may be required.

Inspector's Note: The components of a slurry surfacing system are expressed as a percentage of the weight of the dry aggregate.

2. Slurry Seal Design

The following laboratory tests are referenced in the mix design sections of ISSA's A105 "Recommended Performance Guideline for Emulsified Asphalt Slurry Seal" and ISSA's A115 "Recommended Performance Guideline for Polymer-Modified Emulsified Asphalt Slurry Seal – Provisional". All of the ISSA documents are available as free downloads at ISSA's website www.slurry.org.

- **Laboratory Test Method for Wet Track Abrasion of Slurry Surfacing Systems (ISSA TB No. 100)**
  This test measures the wearing qualities of the slurry seal mixture and determines the minimum emulsified asphalt content.
- **Test Method for Measurement of Slurry Seal Consistency (ISSA TB No. 106)**
  This test measures the flow characteristics of and provides a numerical value for slurry seal consistency during lab evaluations. NOTE: This test may not be applicable to certain quick-set and quick-traffic systems.
- **Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded Wheel Tester and Sand Adhesion (ISSA TB No. 109)**

This test measures the flushing resistance of cured slurry seal systems and determines the maximum emulsified asphalt content in heavy-traffic applications.

- **Test Method for Determining Mix Time for Slurry Surfacing Systems (ISSA TB No. 113)**
  This test verifies raw material compatibility and establishes the proper component proportions needed to ensure sufficient mix time for product application.
- **Test Method for Wet Stripping of Cured Slurry Surfacing Mixtures (ISSA TB No. 114)**
  This test is used to indicate the potential for stripping which may lead to premature raveling.
- **Test Method to Determine Set and Cure Development of Slurry Surfacing Systems by Cohesion Tester (ISSA TB No. 139)**
  This test quantifies the time required before a slurry surfacing system may be subjected to straight rolling traffic.

Additional test methods may include:

- **Determination of Slurry Seal System Compatibility (ISSA TB No. 115)**
  This test is used to evaluates slurry seal component compatibility. NOTE: This test may not be applicable to certain quick-set and quick-traffic systems.
- **Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate (ASTM C29 & AASHTO T19)**
  This test method is used to determine the quantitative effects of moisture content on the unit weight of aggregate (bulking effect).
- **Standard Practices for Design, Testing, and Construction of Slurry Seal (ASTM D3910)**
  These practices cover the design, testing and construction of mixtures for slurry seal systems.

3. Micro Surfacing Design

The following laboratory tests are referenced in the mix design section of ISSA's A143 "Recommended Performance Guideline for Micro Surfacing". All of the ISSA documents are available as free downloads at ISSA's website www.slurry.org.

- **Laboratory Test Method for Wet Track Abrasion of Slurry Surfacing Systems (ISSA TB No. 100)**
  This test measures the wearing qualities of the micro surfacing mixture and determines the minimum emulsified asphalt content.
- **Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded Wheel Tester and Sand Adhesion (ISSA TB No. 109)**
  This test measures the flushing resistance of cured micro surfacing systems and determines the maximum emulsified asphalt content in heavy-traffic applications.
- **Test Method for Determining Mix Time for Slurry Surfacing Systems (ISSA TB No. 113)**
  This test verifies raw material compatibility and establishes the proper component proportions needed to ensure sufficient mix time for product application.
- **Test Method for Wet Stripping of Cured Slurry Surfacing Mixtures (ISSA TB No. 114)**

This test is used to indicate the potential for stripping which may lead to premature raveling.

- **Test Method to Determine Set and Cure Development of Slurry Surfacing Systems by Cohesion Tester (ISSA TB No. 139)**
  This test quantifies the time required before a slurry surfacing system may be subjected to straight rolling traffic.
- **Test Method for Classification of Slurry Surfacing Materials Compatibility by Schulze-Breuer and Ruck Procedures (ISSA TB No. 144)**
  This test method provides a rating system for abrasion loss, integrity and adhesion characteristics of a mixture of aggregate fines of specific gradation and emulsified asphalt residue.
- **Test Method for Measurement of Stability and Resistance to Compaction, Vertical and Lateral Displacement of Multilayered Fine Aggregate Cold Mixes (ISSA TB No. 147)**
  This test measures the ability of a system to resist deformation due to excess binder content, binder rheology, and aggregate characteristics.

Additional test methods may include:

- **Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate (ASTM C29 & AASHTO T19)**
  This test method is used to determine the quantitative effects of moisture content on the unit weight of aggregate (bulking effect).
- **Standard Practice for Design, Testing, and Construction of Micro Surfacing (ASTM D6372)**
  These practices cover the design, testing and construction of mixtures for micro surfacing systems.

<u>Inspector's Note:</u> The percentage of each individual mix component shall be shown in the laboratory report. Based on field conditions, it may be necessary to make adjustments to components within the specific ranges reported on the mix design. Proportion adjustments to emulsified asphalt content in the field should be reported to the inspector in a timely manner.

4. Material Proportioning

Aggregate gradation directly affects the amount of emulsified asphalt required for slurry surfacing systems. Fine aggregates have larger surface area per unit weight. More surface area requires more emulsified asphalt to adequately coat the aggregate. The residual asphalt content required can vary significantly among the three standard aggregate gradations. The design gradation can also vary within allowable tolerances (gradation bands), thus affecting the residual asphalt content. For example, an increase in the percent passing on a particular sieve, especially the No. 100 or No. 200, could significantly influence the residual asphalt content required. The mix design must be completed with samples that are representative of actual materials to be used on the project.

The project mix design dictates the required residual asphalt content of the mixture which is not the same as the emulsified asphalt content of the mixture. Residual asphalt is the actual solids remaining from the emulsified asphalt after the slurry surfacing system has fully cured and the water has evaporated. The emulsified asphalt content of the mixture is calculated by dividing the mixture residual asphalt content (from the mix design) by the emulsified asphalt's residual (from the emulsified asphalt supplier).

Example: For an emulsified asphalt with a residual asphalt content of 63.4%, if the design required a mixture residual asphalt content of 8.2% for a Type II aggregate gradation, the emulsified asphalt content required would be $8.2 \div 0.634 = 12.9\%$.

Residual asphalt, based on the weight of dry aggregate, normally falls within the ranges shown in Table 2.

<table>
<tr><th colspan="3">Residual Asphalt</th></tr>
<tr><th>Gradation Designated</th><th>Slurry Seal</th><th>Micro Surfacing</th></tr>
<tr><td>Type I</td><td>10.0% - 16.0%</td><td>N.A.</td></tr>
<tr><td>Type II</td><td>7.5% - 13.5%</td><td rowspan="2">5.5% - 10.5%</td></tr>
<tr><td>Type III</td><td>6.5% - 12.0%</td></tr>
</table>

Table 2 - Residual Asphalt in Slurry Seal and Micro Surfacing

At least seven working days prior to the placement of the slurry surfacing system, the contractor should submit a signed laboratory mix design utilizing the specific materials to be used on the project. (See the Designer's Note in Section IV.A, page 21, Slurry Surfacing Mix Design.) The mix design must be completed by a laboratory capable of performing the required ISSA tests.

<u>Inspector's Note:</u> The mix design should include the optimum JMF and recommended ranges of aggregate, mineral filler, and emulsified asphalt. This information becomes the basis of material proportioning for constructing the slurry surfacing system. It should also report the test results on the raw materials submitted, as well as the performance results of the mixture.

V. EQUIPMENT CALIBRATION

The application equipment is calibrated to produce a mixture that is consistent with the JMF in the approved mix design. Mix design components are proportioned by weight while the application equipment delivers materials by volume. It is essential that calibration be completed using the actual job materials, immediately prior to each job start-up and in the presence of the Buyer's Authorized Representative (B.A.R.). No application equipment should be allowed to work on a job without a proper calibration.

<u>Inspector's Note:</u> Sample mix designs (for JMF sections), blank calibration worksheets, charts and other useful information are found in the Appendices.

A. Calibration Theory

In slurry surfacing systems, the mix design component proportions are based on the weight of dry aggregate. Therefore, corrections for moisture in the aggregate are necessary. Setting the application equipment feed rates of emulsified asphalt, aggregate, mineral filler, water and additives is critical to the successful application of a slurry surfacing system. Additionally, if multiple pieces of application equipment are utilized on the project, calibration of each one is necessary to ensure mixture and application consistency. The component material output factors identified in the calibration process will assist the contractor and agency in quantifying daily material usage as well as aiding in the verification of application rates.

A proper calibration is based upon the following:

- All JMF weights are based on the dry weight of aggregate. The aggregate in the field or at the calibration site may include moisture, and the weights must be corrected to account for it.
- The emulsified asphalt and aggregate must be mixed according to the prescribed proportions of the JMF, which means calibrating to a common unit such as revolutions of the jackshaft, head pulley, or sprocket. Generally, the head pulley is used. Most contractors will typically refer to the rock/aggregate counter during calibration. This counter is used to quantify both emulsified asphalt and aggregate output.
- A sufficient amount of each component must pass through the application equipment to calculate accurate results, based on weights obtained from certified scales.

Inspector's Note: Newer application equipment uses an electronic control system to control each material individually to obtain the proper ratios as specified in the JMF. Once calibrated, the user enters the desired mix design ratios into a setpoints page. The user will enter the target emulsified asphalt or residual binder, mineral filler and aggregate moisture percentages. The electronic control system will regulate and monitor each function's output rates to meet and maintain the mix design ratios. The machine is equipped with a fixed gate, so the user does not need to adjust any mechanical settings for maintaining a mix design ratio. Water and additive are set by the operator outside of the setpoints page for quick and easy adjustments as needed when ambient conditions change throughout the day. As these electronic control systems are unique to each manufacturer of application equipment, please consult the manufacturer's recommended procedure for calibration.

B. Calibration

Slurry surfacing application equipment requires calibration because it does not mix in batches. Rather, current equipment continuously feeds the individual components (aggregate, emulsified asphalt, mineral filler, water and additive) to the front of the pugmill (mixing chamber), while a homogeneous mixture of all these components is continuously delivered out of the back of the pugmill to the spreader box.

Designer's Note: Continuous feed should not be confused with continuous paving. In a truck-mounted operation, the materials are fed as a continuous feed of raw materials. The application equipment places material until the paver is empty and then returns to the stockpile to refill. In a continuous paving operation, the materials are also fed as a continuous feed of raw materials, but the application equipment stays on the jobsite, while mobile support units (also called nurse trucks) bring the raw materials to the application equipment, thereby allowing the paving operation to be continuous.

Inspector's Note: *Since most application equipment calibrations use the head pulley which turns the aggregate belt, it is easiest to start with no aggregate on the machine and calibrate other items first. This eliminates the need to clean out the aggregate hopper after calibration.*

Emulsified Asphalt Calibration Procedure

For Positive Displacement Pumps:

1. Fill the application equipment with emulsified asphalt.
2. Connect one end of a hose to the emulsified asphalt pump outlet and connect the other to a container sufficiently sized to hold the emulsified asphalt used during calibration. Run the emulsified asphalt pump long enough to fill the connecting hose to ensure that all calibration checks are consistent.
3. Note the identity of the unit for which calibration is being completed as well as the date on the Emulsified Asphalt Calibration worksheet.
4. There are 2 options for determining the sample weights of the emulsified asphalt. Pick the option that will be used to determine how to complete the worksheet.

    Option 1: The application equipment is filled with emulsified asphalt and weighed on a certified truck scale before and after each sample run in order to calculate the sample size. For this option, note the start weight in the “Weight A” column and the end weight in the “Weight B” column on the worksheet. This is the Option displayed in the Emulsified Asphalt Calibration worksheet example.

    Option 2: A container, into which the emulsified asphalt is pumped, is weighed on a certified platform scale before and after each sample run in order to calculate the sample size. For this option, note the start weight in the “Weight B” column and the end weight in the “Weight A” column on the worksheet.

5. Zero the aggregate counter before each sample run.
6. Note the start weight in the appropriate space on the worksheet. Pump the emulsified asphalt for a minimum of 50 counts of the aggregate counter. The resulting sample size should be large enough to ensure greater than 2% accuracy. Minimum sample size is calculated by dividing scale accuracy by 2%.

    Examples of minimum sample size include: 50 lbs. of emulsified asphalt if the scale accuracy is ± 1 lb., 100 lbs. for ± 2 lb. accuracy, 250 lbs. for ± 5 lb. accuracy, or 1000 lbs. for ± 20 lb. accuracy.

7. Once pumping is complete, remove the connecting hose from the container and note the end weight in the appropriate space on the worksheet.
8. Determine the net weight (weight A minus weight B) for the first sample of emulsified asphalt pumped. Divide the net weight by the number of counts of the aggregate belt and record the lbs./count for the first sample.
9. Repeat Steps 5-8 for two additional sample runs, recording the results on the worksheet. It is important to run three calibration samples and then to average the lbs./count of the three samples as illustrated in the completed Emulsifier Asphalt Calibration worksheet.

For Variable Speed Constant Displacement Pumps:

1. Set the emulsified asphalt pump to the factory recommended setting and lock in place.
2. Follow Steps 1-9 above for calibrating the variable speed constant displacement pump.
3. Once calibration is completed, the pump should be locked in place to avoid accidental changes to the flow rate setting.

All emulsified asphalt pumps, regardless of type, should deliver consistent weights so that, once the three runs are averaged, any individual weight should be within ± 2% of the average.

Example: The average emulsified asphalt lbs./count is 4.0. 2% of 4.0 is 0.1, so each individual run should be between 3.9 to 4.1 lbs./count.

If the pump is variable speed constant displacement, over the course of the job, occasionally verify that the pump setting still matches what was used during calibration.

Inspector’s Note: *If the variation is too great and the calibration process must be repeated, emulsified asphalt used in the initial calibration runs should not be used again. Emulsified asphalt that has been pumped back and forth between the container and truck will contain entrained air which will lead to incorrect weights.*

Emulsified Asphalt Calibration Worksheet

Minimum of 50 counts of the rock/aggregate belt counter per sample

Unit Number: 1 Date: 07/01/20

Emulsified Asphalt	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count (= Net Wt/Counts)
Sample 1	58640	56940	1700	425	4.0
Sample 2	56940	55197	1743	425	4.1
Sample 3	55197	53507	1690	425	4.0

Input data in blue shaded cells. Calculate data in white cells.

Average lbs / count of Emulsified Asphalt: 4.0

<u>Inspector's Note:</u> Emulsified asphalt pumps vary among manufacturers. Pumps are either a positive displacement type or a variable speed constant displacement type which can be mechanically set to various rates of flow. Since a variable speed constant displacement pump will not normally be changed during the project, a calibration is necessary only for the setting that the contractor intends to use. Variable speed constant displacement pumps should be equipped with a lock. Calibrate emulsified asphalt to the head pulley revolutions which are displayed on the aggregate counter.

Example of an Emulsified Asphalt Certificate of Analysis (CoA)

Certificate of Analysis

Date 3/19/2021

Product CSS-1HP

State Your State

Facility Location Your City

TEST	MIN	MAX	RESULT
Saybolt Viscosity, 25°C, SSF	20	100	33
Storage Stability, 24 Hr, %	-----	1	0.4
Particle Charge Test Pass fail Mv min	pos	-----	pass
Sieve Test, %	-----	0.1	.04
Residue by Distillation, 177°C, 15 min hold	62	-----	64.5
Penetration, 25°C, 100g, 5 sec, dmm	40	90	80
Softening Point, °F	135.0	-----	136.4
Elastic Recovery, 10°C, HG, 5 cm/min, 20 cm elongation,5 min hold, %	50	-----	58

Mineral Filler Calibration Procedure

1. Fill the fines feeder with the mineral filler to be used on the project.
2. Engage and run the mineral filler auger for a long enough period of time to ensure that the auger is full and a consistent feed of material is achieved.
3. Note the identity of the unit for which the calibration is being completed as well as the date on the Mineral Filler Calibration worksheet.
4. Zero the mineral filler counter before each sample run.
5. Weigh an empty container on a certified scale and note the empty weight on the worksheet. Place the container under the mineral filler delivery port.
6. Engage the mineral filler auger and run a minimum of 10 counts of the fines feeder. The resulting sample size should be large enough to ensure greater than 2% accuracy. Minimum sample size is calculated by dividing scale accuracy by 2%.

   Example: Minimum sample size would be 5 lbs. of mineral filler if the scale accuracy is ± 0.1 lb.
7. After delivery of the mineral filler is complete, note the full weight on the worksheet. Determine the net weight (full minus empty) of the first sample. Divide the net weight of the mineral filler by the number of counts of the fines feeder and record the lbs./count for the first sample.
8. Empty the container and repeat Steps 4-7 for two additional sample runs and record the results on the worksheet. It is important to run three calibration samples and average the lbs./count of the three samples as illustrated in the completed worksheet below.

The fines feeder should deliver consistent weights so that, once the three runs are averaged, any individual weight should be within ± 2% of the average.

Example: The average mineral filler is 0.25 lbs./count. 2% of 0.25 is 0.01, so each individual run should be between 0.24 to 0.26 lbs./count.

Over the course of the job, occasionally verify that the machine setting for the mineral filler still matches what was used during calibration.

Inspector's Note: Various types of application equipment use different methods of supplying mineral filler. Some equipment is mechanically connected to the head pulley while most others are hydraulically matched through a ratio meter. Mechanical feeders have a gate setting similar to that of the aggregate belt. Hydraulic units have a hydraulic flow adjustment.

Mineral Filler Calibration Worksheet

Minimum of 10 counts of the fines feeder counter per sample

Unit Number: 1 Date: 07/01/20

Emulsified Asphalt	Full Weight (Lbs)	Empty Weight (Lbs)	Net Weight (Lbs) (= Full-Empty)	Number of Counts	Lbs /Count (= Net Wt/Counts)
Sample 1	6.0	1.0	5.0	20	0.25
Sample 2	6.1	1.0	5.1	20	0.26
Sample 3	6.0	1.0	5.0	20	0.25

Input data in blue shaded cells. Calculate data in white cells.

Average lbs / count of Mineral Filler 0.25

Aggregate Calibration Procedure

1. If oversized material is present in the stockpile, screen the aggregate prior to loading and calibrating the application equipment.
2. Choose three gate settings (3”, 4”, and 5” are typical examples) at which to calibrate the aggregate and record them on the Aggregate Calibration worksheet. Also, note the unit for which the calibration is being completed as well as the date on the worksheet.
3. Determine the moisture content of the aggregate and calculate the moisture factor which is used to convert the wet aggregate weight into dry aggregate weight. The moisture factor equals the moisture in the aggregate (in decimal form) plus 1.00. For each gate setting on the worksheet, record the moisture factor in the spaces provided.

    Example: If the moisture is 5%, the moisture factor is 1.05.
    Calculation: 0.05 + 1.00 = 1.05

    Designer’s Note: A proven moisture content test method such as AASHTO T 255, Standard Method of Test for Total Evaporable Moisture Content of Aggregate by Drying, or a mutually agreed upon test method for aggregate moisture content determination, should be utilized.

4. To ensure consistent calibration, ensure the aggregate belt is charged with rock/aggregate.
5. Set the gate to the smallest opening chosen for calibration. (In the case of the typical examples given in Step 2 above, that would be the 3” setting).
6. There are 2 options for determining the sample weights of the aggregate. Pick the option that will be used to determine how to complete the worksheet.

    Option 1: The application equipment is filled with aggregate and weighed on a certified truck scale before and after each sample run in order to calculate the sample size. For this option, note the start weight in the “Weight A” column and the end weight in the “Weight B” column on the worksheet. This is the option displayed in the Aggregate Calibration worksheet example.

    Option 2: A container, into which the aggregate is delivered, is weighed on a certified platform scale before and after each sample run in order to calculate the sample size. For this option, note the start weight in the “Weight B” column and the end weight in the “Weight A” column on the worksheet.

7. Zero the aggregate counter before each sample run.
8. Run a minimum of 50 counts of the aggregate belt. The resulting sample size should be large enough to ensure greater than 2% accuracy. Minimum sample size is calculated by dividing scale accuracy by 2%.

    Examples of minimum sample size include: 50 lbs. of aggregate for a platform scale with ± 1 lb. accuracy or 1000 lbs. for a truck scale with ± 20 lb. accuracy.

9. After delivery of the aggregate is complete, note the end weight in the appropriate space on the worksheet.
10. Determine the net weight (weight A minus weight B) for the first sample. Divide the net weight of the aggregate by the number of counts of the aggregate belt and record the lbs./count of the wet aggregate for the first sample.
11. Repeat Steps 7-10 for two additional sample runs at the same gate opening and record the results on the worksheet. It is important to run three calibration samples at each gate opening and then to average the lbs./count of wet aggregate for the three samples as illustrated in the completed worksheet example.
12. Calculate the average dry aggregate lbs./count for the gate opening by dividing the average wet aggregate lbs./count by the moisture factor determined in Step 3. Record the average dry aggregate lbs./count in the appropriate space on the worksheet for the gate setting.
13. Set the gate to the second gate opening and repeat Steps 7-12, then set the gate to the third gate opening and repeat Steps 7-12 again. To ensure consistent calibration ensure the aggregate belt is recharged after resetting the gate each time.

The aggregate belt should deliver consistent weights so that the deviation for any individual sample run should not exceed 2% of the mathematical average of the three runs.

Example: The average wet aggregate lbs./count at the 3” gate setting is 26.2. 2% of 26.2 is 0.5, so each individual run at the 3” gate setting should be between 25.7 and 26.7 lbs./count.

Aggregate Calibration Worksheet

Minimum of 50 counts of the rock/aggregate belt counter per sample

Unit Number: 1 Date: 07/01/20

Gate Setting (inches) 3	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count Wet Aggregate (=Net Wt/Counts)
Sample 1	57300	56000	1300	50	26.0
Sample 2	56000	54690	1310	50	26.2
Sample 3	54690	53370	1320	50	26.4
Avg Wet Agg lbs/count	26.2	÷ Moisture Factor	1.05	= Avg Dry Agg lbs/count	25.0

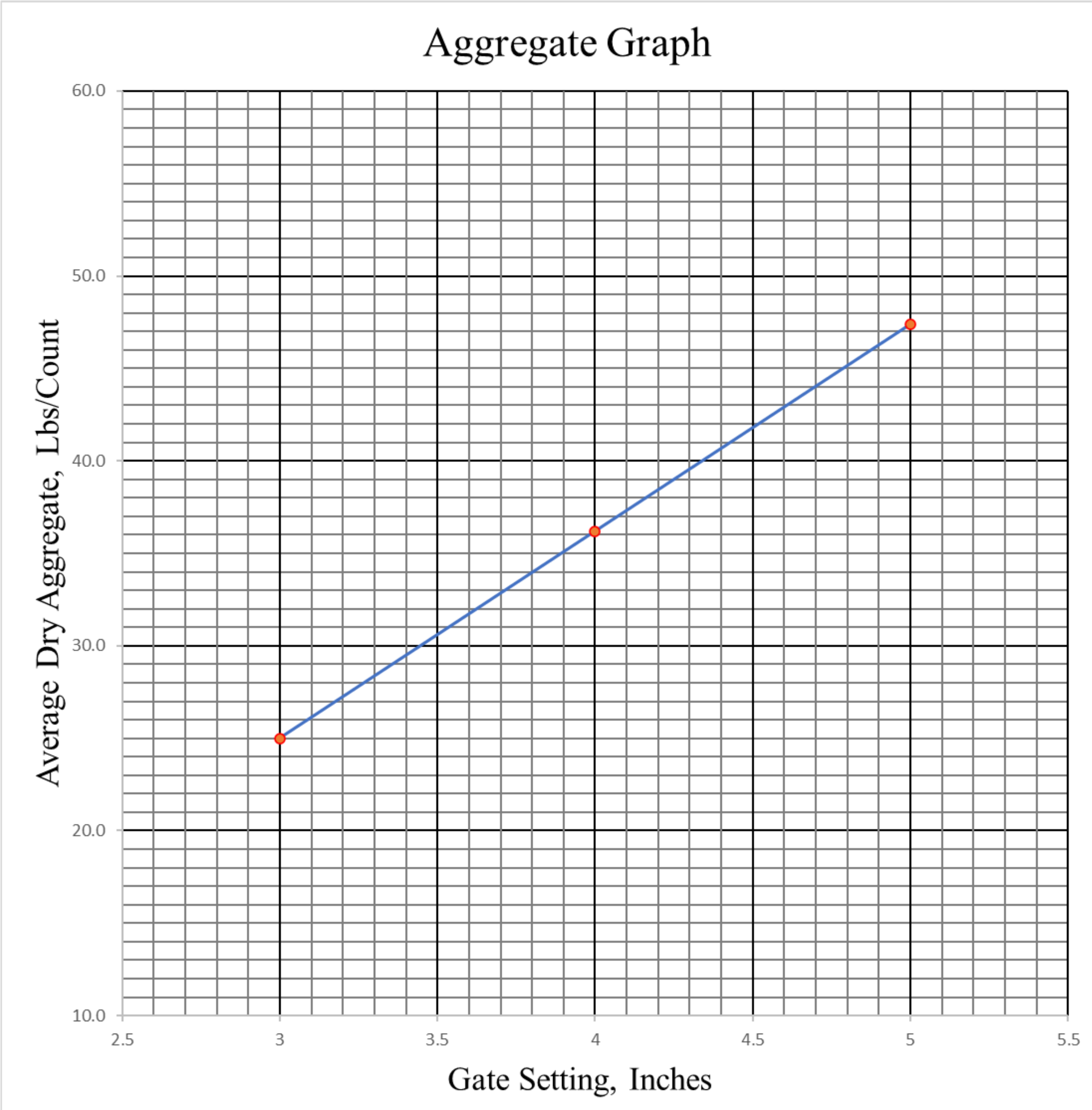
Gate Setting (inches) 4	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count Wet Aggregate (=Net Wt/Counts)
Sample 1	52835	50945	1890	50	37.8
Sample 2	50945	49045	1900	50	38.0
Sample 3	49045	47135	1910	50	38.2
Avg Wet Agg lbs/count	38.0	÷ Moisture Factor	1.05	= Avg Dry Agg lbs/count	36.2

Gate Setting (inches) 5	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count Wet Aggregate (=Net Wt/Counts)
Sample 1	46650	44150	2500	50	50.0
Sample 2	44150	41680	2470	50	49.4
Sample 3	41680	39190	2490	50	49.8
Avg Wet Agg lbs/count	49.7	÷ Moisture Factor	1.05	= Avg Dry Agg lbs/count	47.4

Input data in blue shaded cells. Calculate data in white cells.

Graphing Aggregate Calibration Data

1. Find the average dry aggregate lbs./count for the smallest gate setting on the Aggregate Calibration worksheet. The value in the example is 25.0 lbs./count for the 3" gate setting.
2. On the Aggregate Graph on page 32, mark the data point at the intersection of 3 inches on the x axis (Gate Setting) and 25.0 lbs./count on the y axis (Average Dry Aggregate).
3. Find the average dry aggregate lbs./count for the second and third gate settings on the Aggregate Calibration worksheet. The values in the example are 36.2 lbs./count for the 4" gate setting and 47.4 lbs./count for the 5" gate setting.
4. On the Aggregate Graph, mark the data points at the intersection of 4 inches on the x axis (Gate Setting) and 36.2 lbs./count on the y axis (Average Dry Aggregate) and at the intersection of 5 inches on the x axis (Gate Setting) and 47.4 lbs./count on the y axis.
5. Use a ruler or straightedge to draw a line connecting the individual data points. This line should be reasonably straight.


Aggregate Graph
60.0
50.0
40.0
30.0
20.0
10.0
Average Dry Aggregate, Lbs/Count
2.5
3
3.5
4
4.5
5
5.5
Gate Setting, Inches

Calibration Summary Determination of Gate Setting using the JMF
Once the emulsified asphalt, mineral filler and aggregate feeds have been calibrated, the application equipment must be set to produce a mixture that matches the target JMF from the mix design. The residual binder content of the emulsified asphalt used in the mix design process may not be the same as the residual binder content of the emulsified asphalt used on the project. For this reason, it is preferrable to calculate the gate setting using Method A. Method A: Gate setting calculation using percent residual binder content in the mix (preferred) 1. Record the average lbs./count of emulsified asphalt from the Emulsified Asphalt Calibration worksheet in the appropriate cell on the Calibration Summary worksheet on page 34. From the example on page 28, this value is 4.0 lbs./count of emulsified asphalt. 2. Record the residual binder content of the emulsified asphalt (in decimal form) on the Calibration Summary worksheet. This value can be found on the manufacturer's Certificate of Analysis (CoA) for the material delivered to the project. From the example CoA on page 28, the value is 64.5%. 3. Record the target JMF residual binder content of the mixture (in decimal form) on the Calibration Summary worksheet. This value can be found on the mix design. From the example mix design on page 108, the value is 7.7%. 4. Multiply the average lbs./count of emulsified asphalt by the percent residual binder content of the emulsified asphalt (in decimal form) and divide by the target JMF percent residual binder content of the mixture (in decimal form) to calculate the dry aggregate lbs./count required to match the target JMF residual binder content of the mixture from the mix design. In the example below, the value is 33.5 dry aggregate lbs./count. 5. On the Aggregate Graph on page 35, find the dry aggregate lbs./count calculated in Step 4 on the y axis and follow that line horizontially until it intersects the line drawn on the graph. Then, follow the line down vertically to the x axis to determine the gate setting required to deliver the dry aggregate lbs./count required to match the target JMF residual binder content. In the example below, the gate setting is 3.75". Method B: Gate setting calculation using percent emulsified asphalt content in the mix 1. Record the average lbs./count of emulsified asphalt from the Emulsified Asphalt Calibration worksheet in the appropriate cell on the Calibration Summary worksheet. From the example on page 28, this value is 4.0 lbs./count of emulsified asphalt. 2. Record the target JMF emulsified asphalt content in the mixture (in decimal form) on the Calibration Summary worksheet. This value can be found on the mix design. From the example mix design on page 108, the value is 11.9%. 3. Divide the average lbs./count of emulsified asphalt by the target JMF percent emulsified asphalt content of the mixture (in decimal form) to calculate the dry aggregate lbs./count required to match the target JMF emulsified asphalt content of the mixture from the mix design. In the example below, the value is 33.6 dry aggregate lbs./count. 4. Determine the gate setting using the dry aggregate pounds/count just calculated in Step 3 as described in Step 5 of Method A, above. In this example, the gate setting is 3.75". Over the course of the job, occasionally verify that the gate setting matches what was determined during calibration.

Calibration Summary Worksheet

Unit Number: 1　　　　　　　　Date: 07/01/20

Determination of Gate Setting

Choose the calculation procedure (below) based on the information provided on the mix design.

A. GATE SETTING CALCULATION USING PERCENT RESIDUAL BINDER CONTENT IN THE MIX (PREFERRED)

1. Average lbs/count of emulsified asphalt from Emulsified Asphalt Calibration worksheet	4.0
2. Percent residual binder content of the emulsified asphalt (provided on the supplier CoA with the load)	64.5
3. Percent residual binder content of the mixture (from the JMF on the mix design)	7.7

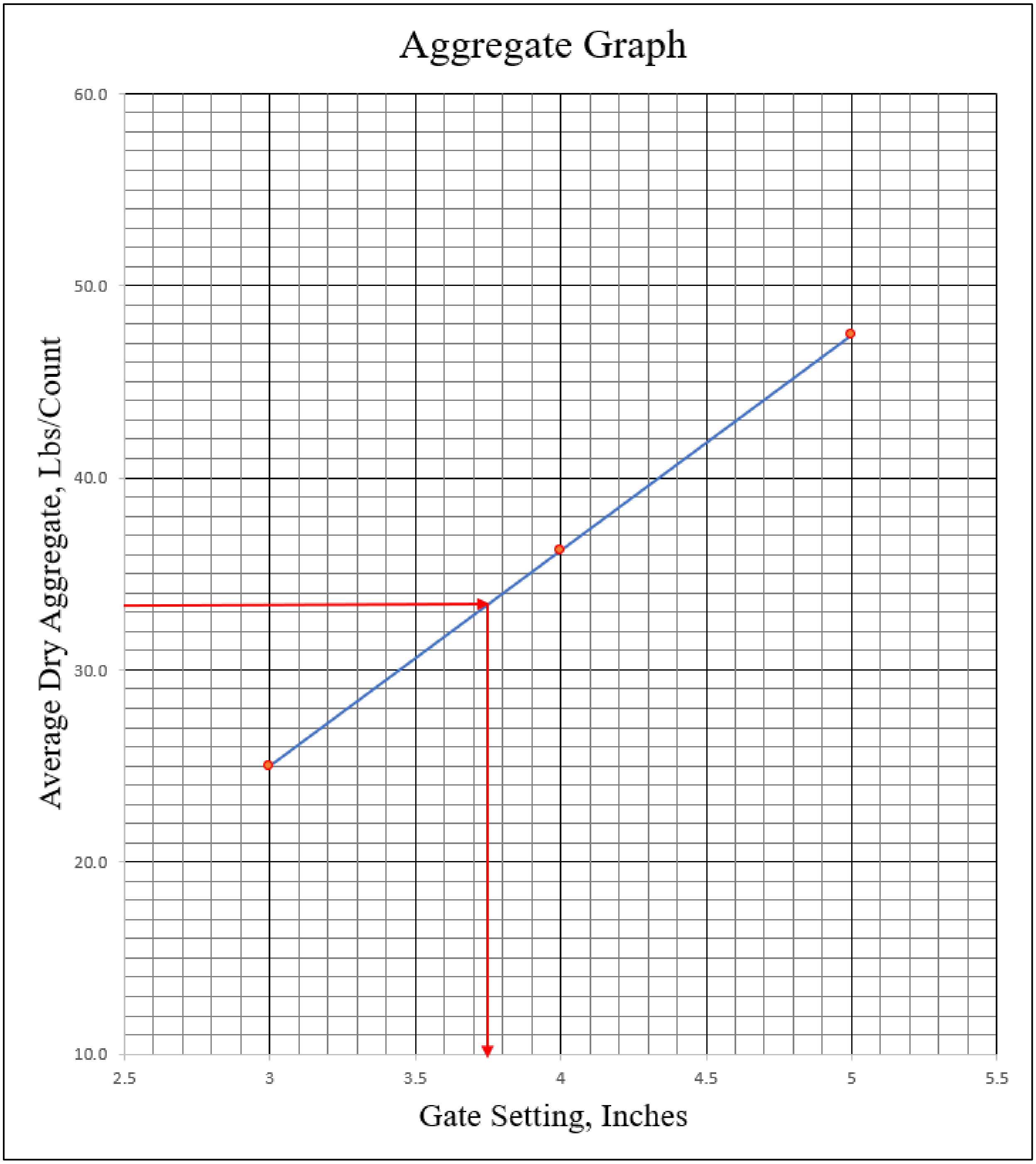
	Average lbs/count emulsified asphalt		Residual binder content of the emulsified asphalt (in decimal form)		Target JMF residual binder content of the mixture (in decimal form)		Dry aggregate lbs/count required to match target JMF residual of the mix	
4.	4.0	X	0.645	÷	0.077	=	33.5	
5. Gate setting required to provide dry aggregate lbs/count calculated in Step 4						=	3.75	inches

B. GATE SETTING CALCULATION USING PERCENT EMULSION CONTENT IN THE MIX

1. Average lbs/count of emulsified asphalt from Emulsified Asphalt Calibration worksheet	4.0
2. Percent emulsified asphalt content (from the JMF on the mix design)	11.9

	Average lbs/count emulsified asphalt		Percent emulsified asphalt content in the mixture (in decimal form)		Dry aggregate lbs/count required to match target JMF emulsion content of the mix	
3.	4.0	÷	0.119	=	33.6	
4. Gate setting required to provide lbs aggregate/count calculated in Step 2				=	3.75	inches

Input data in colored/shaded cells. Calculate data in white cells.


Aggregate Graph
Average Dry Aggregate, Lbs/Count
Gate Setting, Inches
60.0
50.0
40.0
30.0
20.0
10.0
2.5
3
3.5
4
4.5
5
5.5

Mineral Filler Summary
Determination of Mineral Filler Speed Control Setting at JMF

1. Enter the dry aggregate lbs./count into the Mineral Filler Summary worksheet below. This value was determined in Method A, Step 4 or Method B, Step 3 of the Calibration Summary-Determination of Gate Setting procedure.
2. Determine the aggregate counts/minute at the desired production rate by running the aggregate belt for one minute and recording the total number of counts on the Mineral Filler Summary worksheet below.
3. Multiply the dry aggregate lbs./count by the aggregate counts/minute to determine the total output of dry aggregate/minute of production.
4. Record the percent mineral filler target from the JMF on the mix design on the Mineral Filler Summary worksheet example. This value can be found on the mix design. From the example mix design on page 108, the value is 1%.
5. Multiply the dry aggregate lbs./minute by the target JMF percentage of mineral filler (in decimal form) to determine the mineral filler lbs./minute required to match the target JMF for this output of aggregate. In the example below, the value is 35.2 mineral filler lbs./minute.
6. Enter the average mineral filler lbs./count from the Mineral Filler Calibration worksheet. From the example on page 29, this value is 0.25 lbs./count.
7. Determine the mineral filler counts/minute by dividing the mineral filler lbs./minute by the mineral filler lbs./count. In the example below, the value is 141 mineral filler counts/minute.
8. Adjust the mineral filler feeder to achieve 141 mineral filler counts/minute.

Mineral Filler Summary Worksheet

Unit Number: 1 07/01/20

Determination of Fines Feeder Speed Control Setting at JMF

1. Average dry aggregate lbs/count from the Calibration Summary worksheet (Method A, Step 4 or Method B, Step 3) 33.5
2. Aggregate counts/minute at desired production rate 105

	Dry aggregate lbs/count		Aggregate counts/minute		Dry aggregate lbs/minute
3.	33.5	x	105	=	3517.5

4. Percent mineral filler (target from the JMF on the mix design) 1.0

	Dry aggregate lbs/minute		Target JMF mineral filler dosage (in decimal form)		Mineral filler lbs/minute required to match JMF from mix design
5.	3517.5	x	0.01	=	35.2

6. Average mineral filler lbs/count from the Mineral Filler Calibration worksheet 0.25

	Mineral filler lbs/minute required to match JMF from mix design		Mineral filler lbs/count		Mineral filler counts/minute
7.	35.2	÷	0.25	=	141

Input data in colored cells. Calculate data in white cells.

Inspector's Note: Over the course of the job, occasionally verify that the mineral filler speed control and aggregate gate settings match that which was determined during calibration. If a variable speed constant displacement pump was used, verify that the flow rate setting used during calibration remains unchanged.

VI. CONSTRUCTION OF SLURRY SURFACING SYSTEMS

A. Stockpile

The stockpile or staging area is where the contractor will store equipment and materials for the duration of the project. It should be in a centralized location to reduce haul times, resulting in higher production levels. It should be a structurally sound, hard surface, such as gravel or pavement, and should be located on high ground that remains dry after rain events. It is the contractor's responsibility to keep the staging area clean and orderly.

Easy access to the project, as well as access to a fire hydrant are important considerations when determining stockpile locations. However, equipment noise, dust, and high volumes of incoming/outgoing truck traffic are reasons to avoid locating the project stockpile near a residential area.

Most agencies have property that will serve well for a stockpile. In cases where agency property is unavailable, the agency usually assists the contractor in locating local landowners for a stockpile area.

Figure 6 - Typical Aggregate Stockpile

Precautions should be taken to ensure that the stockpiled materials do not become contaminated or contaminate the staging area. In spite of normal precautions taken with the aggregate, an occasional stone having dimensions greater than the treatment application thickness may get into the aggregate bin. These oversized stones eventually become lodged under the lower edge of the rear screed and cause unsightly longitudinal grooves in the finished surface.

Some aggregate types tend to dry in lumps or balls when exposed to rain, as well. The drier these lumps become, the more difficult it is to break them up into individual aggregate particles. If oversized stones or lumps are a problem, a screening plant at the stockpile should be used to remove the oversized material. Aggregate should be screened directly into the application equipment or support vehicles (See Figure 6). In arid climates and where dust abatement regulations prohibit the use of screening plants, it is important to take other precautions to guard against this type of contamination. In this case, working closely with the quarry and trucking firms to eliminate contamination may be necessary.

<u>*Inspector's Note:*</u> *It is important that all stockpile areas are kept clean and orderly throughout the project, including a thorough cleanup of the site once the project is completed. Daily inspection of the loading area is suggested, with emphasis on the emulsified asphalt loading area.*

B. Surface Preparation

There are two stages of surface preparation: early and final. The early stage should be completed well in advance of project start-up. The final stage should be completed immediately before the project begins.

1. Early Stage

The early stage of surface preparation includes:

- Repair of underground utilities, such as culverts and water leaks;
- Repair of concrete driveways, sidewalks, curbs and gutters;
- Surface patching of the areas showing high levels of distress;
- Full-depth repairs of areas showing base failure;
- Structural leveling with hot mix asphalt;
- Trimming of low hanging limbs to ensure access to the pavement for the application equipment;
- Grading the shoulders back;
- Herbicide treatment, making for easier removal of the vegetation and retard future growth;
- Crack sealing.

<u>Designer's Note:</u> It is recommended that cracks 0.25 inch and larger be sealed prior to the installation of slurry surfacing systems. It is also recommended that this crack sealing phase of construction be performed in advance of surfacing. Crack treatments should be completed with a suitable sealer and the amount of sealer remaining on the pavement surface should be minimal. There are two different methods of crack sealing: blow and seal, or rout and seal. It is recommended that you consult with your ISSA contractor or crack seal supplier to determine the appropriate method. Go to the ISSA website (www.slurry.org/page/guidelines) to download ISSA's A175 "Recommended Performance Guideline For Crack Treatment" at no charge.

Any items above not completed in a timely fashion or left unaddressed will negatively affect final project performance.

Figure 7 - Proper Pre-Application Patchwork

Figure 8 - Crack Treatment Prior to Application

2. **Final Stage**

The final stage of surface preparation includes surface cleaning, protection of structures and utility castings and removal of pavement markings.

Surface Cleaning

Prior to applying the slurry surfacing, existing vegetation shall be removed. The pavement shall be swept, and all loose materials removed. Acceptable methods for sweeping include the use of vacuum assisted and rotary brooms, as seen here.

Figure 9 - Surface Cleaning to Remove Tracked Dirt and Mud

Figure 10 - Vacuum-Assisted Sweeper

Use of forced air may be suitable in some situations, such as in areas that may be difficult to access with larger equipment. Blowing also aids in the removal of fine particulates that cannot be easily removed by the sweeping operation. These finer particulates can interfere with bonding of the slurry surfacing and must be removed prior to application.

In areas where mud and dirt have been tracked onto the pavement, it may be necessary to use pressurized water to remove the objectionable material. If pressurized water is not available, water combined with brooming, as shown in Figure 9 may satisfactorily remove the objectionable material from the pavement.

In parking lots and on streets with curb side parking, the contractor may encounter oil spots on the pavement. It is recommended that industrial detergents, pressure washing, and/or grinding be used to remove any material that may serve as a barrier to bonding. Severity of oil damage may require that removal and replacement of the pavement is necessary.

Protection of Structures and Utility Castings

Prior to applying the slurry surfacing, protecting areas not scheduled to be covered is extremely important. These include utility structures, such as manhole covers, catch basins, and valve boxes. Other areas include bridge decks, decorative crosswalks, concrete valley gutters and airplane tie downs. Taping plastic sheeting or roofing felt to these structures is a proven method for their protection. Once the utility has been taped off, it is important to mark a reference point or to use flexible, temporary chip seal markers to assist in locating the utility once it has been covered by the slurry surfacing. The following series of pictures show a properly taped manhole cover (Fig. 11), the same manhole cover clearly visible after slurry surfacing is applied over it (Fig. 12), and the finished appearance after the manhole's protective sheeting/taping has been removed (Fig.13).

Figure 11 - Flexible, Temporary Chip Seal Marker and Properly Utility Masking

Figure 12 - Flexible, Temporary Chip Seal Marker and Properly Utility Masking (after application)

Figure 13 - Removal of Masking Following Proper Curing of Slurry Surfacing

The use of plastic sheeting or roofing felt may also be used to protect the limits of the project as is shown with the bridge deck in Figure 14. The first photo (a) shows the plastic sheeting taped over the area to be protected from the slurry surfacing materials. The second photo (b) shows the application equipment applying materials over the area that needs protecting. The third photo (c) shows the excess materials remaining after the application equipment has completed the installation. The fourth photo (d) illustrates how the plastic sheeting protected the concrete bridge deck from the slurry surfacing materials. The advantages to using this process include the protection of the bridge deck from asphalt stains and the reduction of handwork. Decorative pavements such as stamped asphalt or concrete crosswalks can also be protected in this manner.

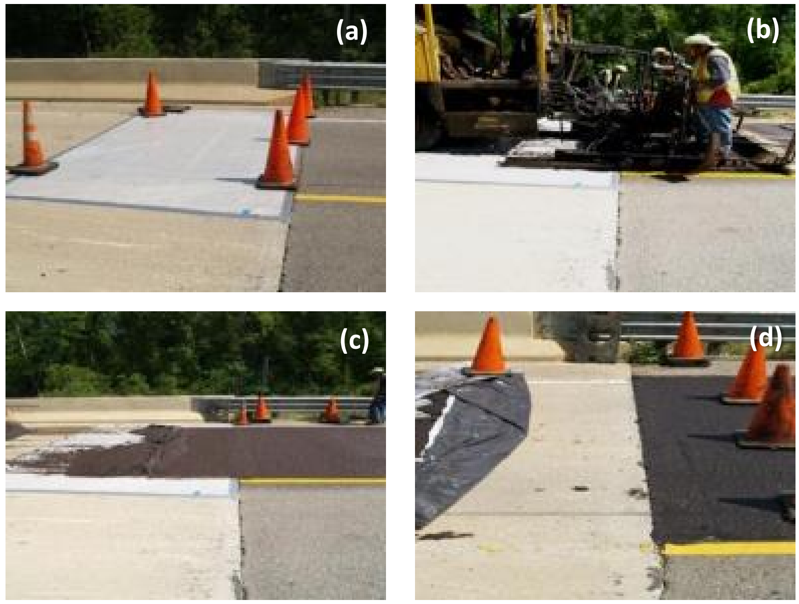


Figure 14 - Protecting Bridge Decks

Once the material has cured, the contractor should remove the masking materials from the jobsite and dispose of them in an acceptable manner. Removal of the masking should take place on the same day as the application and prior to opening the pavement to traffic.

Removal of Pavement Markings

The four types of pavement markings are paint, raised pavement, snow plowable, and thermoplastic.

Paint Markings

Most painted pavement markings will not require any special treatment and the slurry surfacing will bond properly to the marking. However, sometimes new pavement paint markings or markings that have a substantial paint buildup can represent potential bonding concerns for slurry surfacing systems. In these cases, the paint should be removed or abraded to produce a rough surface. In other cases, the paint can be tacked to ensure a good bond.

Raised Pavement Markings

Raised markings are usually made with plastic, ceramic, or occasionally metal, and come in a variety of shapes and colors. Many devices include a lens or sheeting that enhances their visibility by reflecting automotive headlights. Removal of the markers is highly recommended and after the slurry surfacing is completed new markers should be installed.

Snow Plowable Pavement Markings

Snow plowable markers are generally recessed in the pavement and have a reflective lens. It is recommended that these markers be removed in advance of any slurry surfacing application. Suitable asphalt patching material should be used to repair the void left from the removal process. Masking of snow-plowable markers is not generally acceptable as ponding during rain events as well as reduced reflectivity are a common result. It is recommended that these markers be replaced after the slurry surfacing installation.

Figure 15 - Pavement Condition After Removal of Snow Plowable Marker

Figure 16 - Repairing Hole (from previous picture) with High Performance Cold Mix

Thermoplastic Pavement Markings

It is recommended that all thermoplastic pavement markings more than 4 inches wide be removed or at least abraded prior to slurry surfacing installation. The acceptable methods of removal include grinding or water blasting. Removal of 80-85% of the marking will ensure a good bond. Water blasting should not be used in areas with extensive cracking.

C. Notification

Notification about the project can yield positive results for the traveling public, the agency, and the contractor performing the work. It is recommended that the public receive notification and information about the project in both the early and final stages.

Early stage notification can be implemented by the agency itself and includes the use of local newspapers, radio, cable TV, and agency websites. This process should take place a minimum of a few weeks prior to project start up.

The final stage of notification should be performed by the contractor and include a 24-hour notice delivered door to door to those who will be affected by the project. It is important to note that performing a thorough notification will minimize the potential issues that come with an uninformed public.

Insert
Logo
Here

NOTICE OF STREET RESURFACING

<Agency> has selected **<Your Company>** to perform maintenance/pavement preservation in your neighborhood.

WORK TO BE DONE: Slurry Surfacing System consisting of either a Slurry Seal or Micro Surfacing Overlay.

WHERE: Main Street from A Street to Z Street (*If you have a map available, attach to this notice for further clarification*)

PROJECT TIMING: <Date> to <Date> **(Weather Permitting)**

QUESTIONS? Should you have any questions, please contact our office at (123) 456-7890 or by email at questions@contractorswebsite.com

HOW WILL I BE AFFECTED?

- Minor traffic interruptions, noise and dust impacts, and parking restrictions may be expected.
- On the day of application, traffic may be restricted to one lane during paving operations with one lane remaining open for travel. Cul-de-sac streets will be closed to ensure the fastest possible installation, so alternative parking should be used.
- Orange cones will mark off work areas and other areas that should not be driven on.
- In most cases, the surfacing is cured sufficiently to allow pedestrian traffic after one hour and vehicle traffic in about three hours. Cones will be removed when it is dry enough for traffic.
- Trash collection and mail delivery services may occur at different times of day but should not beinterrupted.
- Emergency access will be provided at all times.
- Small rocks may break away from the new surface as it cures. Along with the small amount of surface raveling common to liquid asphalt treatment applications, any necessary sanding at intersections will also be swept within a short period of time.
- All impacts and closures will be minimized to the greatest extent possible.

WHAT CAN I DO TO HELP?

- Trim back all vegetation to at least one foot away from the asphalt pavement.
- Obey traffic and parking signs.
- Don't park on streets the day they are being resurfaced.
- Keep water from entering the street the day work is to be performed. (i.e., turn off lawn and garden sprinklers)

WHAT CAN I EXPECT FROM THE SLURRY SURFACING SYSTEM OVERLAY?

- The color of the treatment is typically light brown when applied but turns black as itdries.
- The coarse texture appearance is not that of a new rolled asphalt street; however, this does not affect the quality as it is not a structural improvement. Rather, the new surface provides a protective coating for the streets and is designed to seal and extend the life of the pavement. The texture will also get smoother with traffic and time.
- The cost for a slurry surfacing system is a fraction of the cost of an asphalt overlay or milling and repaving, making it a very economical method of maintenance.
- Even after streets are re-opened, the new surface may remain tender for a period of time, particularly if placed during warm weather. Normal driving on recently treated streets may cause some tire tracks, especially at the ends of cul-de-sacs, or power steering burns or scuffs from turning wheels while the car is not moving. While this may affect only the appearance of the streets, and many times is unavoidable, much of this will disappear with time and traffic.

PROUD MEMBER OF
THE INTERNATIONAL SLURRY SURFACING ASSOCIATION
www.slurry.org

Figure 17 - Public Notifier

Insert Logo Here

IMPORTANT NOTICE: PLEASE READ CAREFULLY!

YOUR STREET HAS BEEN SELECTED TO RECEIVE A SLURRY SURFACING SYSTEM OVERLAY. THIS IS A THIN, LIQUID ASPHALT OVERLAY THAT WILL GIVE THE STREET A UNIFORM TEXTURE AND RIDING SURFACE WHILE IT PROTECTS THE PAVEMENT BENEATH.

UPON RECEIPT OF THIS NOTICE, PLEASE BE PREPARED FOR US TO BEGIN WORK IN FRONT OF YOUR HOME BY 7 A.M.* ON THE INDICATED DAYS AND DATES:

SUNDAY MONDAY TUESDAY WEDNESDAY

THURSDAY FRIDAY SATURDAY

MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER

OCTOBER NOVEMBER DECEMBER

1 2 3 4 5 6 7 8 9

10 11 12 13 14 15 16 17 18

19 20 21 22 23 24 25 26

27 28 29 30 31

*IMPORTANT INFORMATION ABOUT PARKING AND GETTING AROUND ON REVERSE SIDE.

PROUD MEMBER OF
THE INTERNATIONAL SLURRY SURFACING ASSOCIATION
www.slurry.org

ALL RESIDENTS ARE HIGHLY ENCOURAGED TO VISIT
WWW.CONTRACTORSWEBSITE.COM
FOR MORE DETAILS ABOUT THIS WORK AND HOW TO HELP ENSURE A SAFE AND SUCCESSFUL INSTALLATION.

- IF YOUR ROAD HAS ON-STREET PARKING, PLEASE REMOVE ANY PARKED VEHICLES FROM THE ROADWAY BY 7 A.M. BE AWARE THAT CARS PARKED IN DRIVEWAYS MAY NOT BE ABLE TO GET OUT FOR UP TO AN HOUR AFTER PAVING STARTS.
- THIS MATERIAL NEEDS TO CURE FOR APPROXIMATELY 3 HOURS BEFORE IT CAN BE OPENED TO TRAFFIC.
- WITH THE EXCEPTION OF CUL-DE-SACS, ONE SIDE OF EACH STREET WILL REMAIN OPEN FOR TRAVEL TO AND FROM YOUR HOME.
- WE DO REQUEST THAT IF YOU NEED TO CROSS OVER AN UNOPENED SECTION OF ROADWAY THAT YOU WAIT AT LEAST ONE HOUR AFTER APPLICATION. CROSS STRAIGHT OVER, DO NOT TURN SHARPLY OR YOU WILL DAMAGE THE NEW SURFACE. PLEASE ONLY CROSS THE NEW SURFACE IF YOU MUST. DO NOT CONTINUE TO DRIVE ON THE CLOSED LANE. YOU WILL DAMAGE THE ROAD AND MAY POSSIBLY SOIL YOUR CAR WITH ASPHALT.
- KEEP WATER FROM ENTERING THE STREETS ON THE DAY OF TREATMENT. I.E. LAWN SPRINKLERS
- IF YOU HAVE CONCRETE OR EXPOSED AGGREGATE DRIVEWAYS, DO NOT CROSS OVER THE NEW SURFACE UNTIL THE CONES HAVE BEEN REMOVED FROM THE STREET. THIS WILL PREVENT ASPHALT FROM BEING TRACKED ONTO YOUR DRIVEWAY.
- FOR YOUR OWN SAFETY AND THE SAFETY OF OUR EMPLOYEES PLEASE BE AWARE THAT WHEN YOU LEAVE YOUR DRIVEWAY YOU MAY BE ENTERING OUR WORK ZONE. ALWAYS REMEMBER TO LOOK BOTH WAYS BEFORE EXITING OR ENTERING YOUR DRIVEWAY. IF YOU ENCOUNTER OUR EMPLOYEES OR EQUIPMENT IN YOUR AREA PLEASE SLOW DOWN AND PROCEED WITH CAUTION.

PATCHING, LINE REMOVAL, AND CRACK SEALING HAS ALREADY BEEN PERFORMED IN YOUR AREA. AFTER THE PRESERVATION TREATMENT IS COMPLETE, WE WILL RETURN IN A COUPLE OF WEEKS TO SWEEP NECESSARY AREAS. THE NEW SURFACE NEEDS TWO TO THREE WEEKS TO CURE BEFORE WE CAN APPLY THE LINE MARKINGS. THIS WILL COMPLETE THE ENTIRE PROCESS IN YOUR AREA.

IF YOU HAVE ANY QUESTIONS, THERE WILL BE A REPRESENTATIVE OF <CONTRACTOR> ON THE JOB. CONTRACTOR INQUIRIES PLEASE CALL 123-456-7890

Insert Logo Here

Contractor Name
P.O. Box 1234
Anytown, USA 12345
123-456-7890

Figure 18 - Public Notifier – Door Hanger

NOTE: These documents are available at no charge to ISSA members on the ISSA website (www.slurry.org) for you to "customize" with your company logo, along with project specific information.

D. Traffic Control

Traffic control plans and devices shall meet or exceed the minimum requirements of the "Manual on Uniform Traffic Control Devices" and should meet or exceed the State and local agency requirements. Traffic control should consider the following.

- Safety of the traveling public;
- Safety of the employees performing the work;
- Product protection; and
- Traffic control devices.

In addition, suitable methods shall be used by the contractor to protect the slurry surfacing systems from all types of traffic damage. It is important to remember that opening to traffic does not constitute acceptance of the work.

E. Application

Thorough attention to detail is critical during the application process to ensure a successful final product.

1. Ambient Conditions for Application

The basic prerequisites for successful system application and performance require a proper break and cure. Environmental factors, such as temperature, humidity, wind, and imminent rainfall play a role in the application process of all slurry surfacing systems. As a result, a thorough understanding and consideration of these factors in the formulation of the emulsified asphalt and JMF is essential to optimize product performance.

The breaking, setting and curing time of slurry surfacing systems is influenced by temperature. Slurry surfacing systems should not be applied if the pavement or air temperature is below 10°C (50°F) and falling but may be applied when both pavement and air temperatures are above 7°C (45°F) and rising. Slurry surfacing systems should not be applied when there is the possibility of freezing temperatures at the project location within 24 hours after application.

Lower temperatures will extend the break and set times of slurry surfacing systems and higher temperatures will accelerate the break and set. On warm days, it is common to increase the use of spray bars to fog the pavement. The spray of water helps cool the surface and prevent the emulsified asphalt from breaking on contact with the pavement. Spray bars may not be needed on cool days.

Elevated temperatures, whether ambient, surface or of any mix component, will cause a reduction of available mix time and may require additional water or chemical additive in the mix to counteract the higher air and pavement temperatures. Modifications to additives (usage/dosage) should be made according to the changing environment during application. Humidity may impact the rate of breaking and setting of the slurry surfacing material. Expected environmental conditions should be communicated to the design lab so that emulsified asphalt and mixture formulations can be optimized for actual project conditions.

A slight breeze is advantageous to the setting and curing of slurry surfacing systems. In less humid conditions the breeze may accelerate the breaking and setting process of the slurry surfacing material. Work should not be started if rain is imminent. Micro surfacing will typically resist damage caused by light rain after as little as one hour after placement.

Application of slurry seal is generally not suitable for night work. Micro surfacing can be placed at night because it relies primarily on chemical breaking and curing. Lower evaporation rates at night result in longer breaking and curing times.

Inspector's Note: When first applied or during hot weather, slurry surfacing systems may be tender. Although power steering abrasion is not uncommon and will most often occur in cul-de-sacs, parking lots, or any areas where vehicle turning is restricted, minor surface scuffing should heal itself.

In areas where immediate access is needed, a sand or aggregate blotter may be used to minimize damage. Slurry surfacing systems should not be placed when rain is imminent. Although slurry surfacing systems may be ready for traffic in a short time, some water may remain in the mix for a few hours.

2. Slurry Surfacing System Bonding

The integrity of the slurry surfacing system treatment is ensured by creating a strong bond to the existing pavement.

Pavement Pre-Wetting

Pre-wet the surface by fogging through the spray bars of the application equipment ahead of the spreader box when the surface is dusty, oxidized or hot. If asphalt flushing or bleeding exists, fogging may be required to minimize adhesion of the asphalt to the tires and skids on the application equipment. The rate of application of the fog spray should be adjusted during the day to suit temperatures, existing pavement surface texture, humidity, and dryness of the pavement surface. Water used in the pre-wetting of the surface should be applied such that the entire surface is damp with no flowing water in front of the spreader box.

Figure 19 - Water Spray Bar

Tack Coat

A tack coat preceding a slurry surfacing system treatment may reduce the absorptive nature of the road surface thus improving application success. However, in most cases a tack coat is not required unless the existing road surface is extremely dry, raveled or is concrete or brick. A tack coat, when used for a slurry surfacing system, should be a dilution consisting of one part emulsified asphalt and three parts water, applied with a distributor at 0.45 to 0.68 liters per square meter (0.10 to 0.15 gallons per square yard), depending on the surface texture. The actual rate will depend on the residual asphalt content of the diluted emulsified asphalt and on the texture and absorptive characteristics of the existing surface. The emulsified asphalt may be CSS-1h, SS-1h, or the same as used for the slurry surfacing treatment.

Figure 20 - Tack Coat Distributor

3. **Scratch Course**

A scratch course is only used with micro surfacing primarily to level pavements with longitudinal ruts less than 12.5 mm (0.5 inch) deep. They may also be used to correct minor transverse irregularities that are narrower than the width of the spreader box or for structurally sound roads with surface distresses, such as raveling or weathering. When applying a scratch course, a steel or stiff rubber strike-off, is substituted for the primary strike-off in the standard full-width micro surfacing spreader box. The rigid strike-off scratches over the high spots of the pavement, filling in the irregularities. The concept is to fill the depressed areas and leave very little material on the high ridges. It is common to see scratch marks on the areas identified with arrows (See Figure 21). All scratch course materials should cure under traffic for at least 24 hours before the final surface course is placed. A scratch course is not a stand-alone application and should always be covered with an application of full-width micro surfacing.

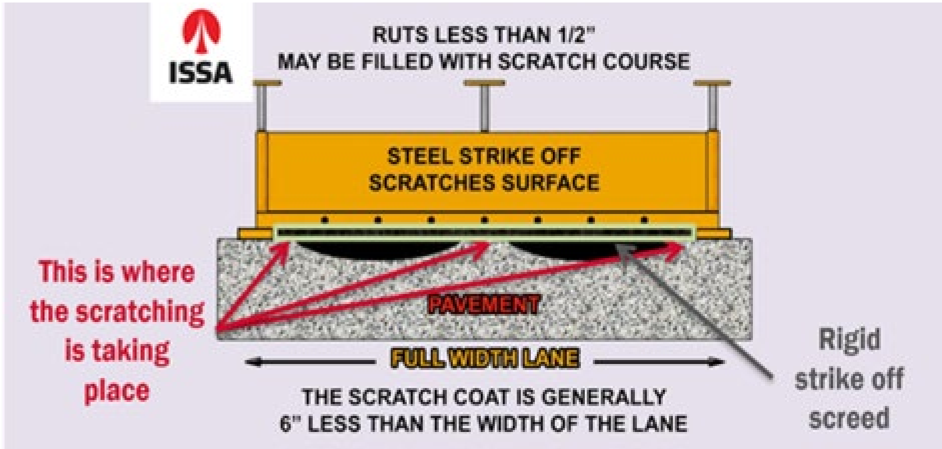


Figure 21 - Illustration of a Typical Section for a Scratch Course

Figure 22 - Scratch Course

Figure 23 - Scratch Course

<u>Inspector's Note:</u> When the surface texture of the existing pavement is non-uniform, the final texture of the micro surfacing may also be non-uniform. Therefore, a scratch course may be needed prior to application of the final surface to create a uniform texture. During the placement of a scratch course individual pieces of aggregate may be caught by the spreader box and pulled along the road surface creating drag marks and scratches. This should be expected between wheel paths and on high spots.

4. Rut Filling

Rut filling should only be performed with micro surfacing and should only be used on stable ruts that have resulted from long-term traffic compaction rather than failures in the base or sub-base. If rutting is ongoing, the micro surfacing will not prevent its continued development.

Use Guide for Rut Filling
Use micro surfacing as a rut filler when: • The pavement is structurally sound. • The rut depth has stabilized. • The ruts were from mechanical compaction over time near the pavement surface and not from base or subgrade failure. • The ruts are gradual depressions, not sharp-sided and flat-bottomed, and not showing dual wheel marks. • The ruts are indentations only, not an indentation between upward heaves (shoving at intersections). • The ruts do not contain fatigue (alligator) cracking.

Figure 24 - Unacceptable Candidate for Rut Filling

Figure 25 - Acceptable Candidate for Rut Filling

<u>Designer's Note:</u> If the pavement is structurally inadequate, a micro surfacing treatment will not provide adequate structural improvement or prevent further deterioration. If the ruts have extensive alligator cracking and shear failure, or result from another serious underlying pavement problem, the pavement can generally be considered structurally inadequate, and filling the ruts will not correct the problem. Ruts less than 12.5 mm (0.5 inch) deep should be addressed with a full-width scratch course for leveling before the final surface is placed. Ruts of 12.5 mm (0.5 inch) or more should be filled individually with a rut box, generally starting with the outside rut first and inside rut last. Ruts filled either with a scratch course or rut box should be covered with an application of full width micro surfacing.

The rut box channels the largest aggregate particles into the deepest areas of the rut. The rut box should be adjusted to create a crown to compensate for traffic compaction.

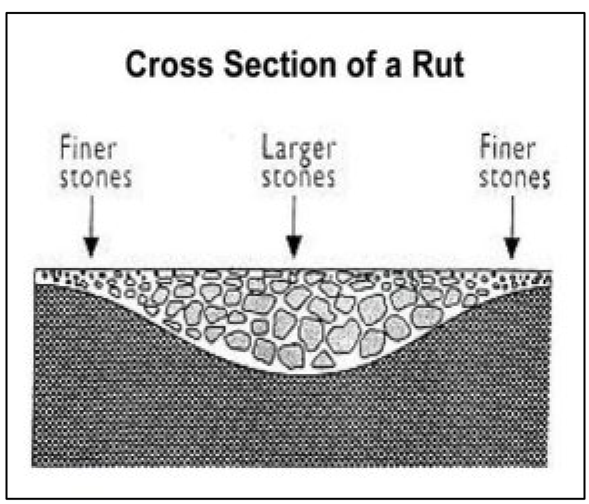


Figure 26 - Aggregate Distribution Within a Rut

Inspector's Note: *Rut repair requires the contractor to slightly overfill the rut to allow for traffic compaction of the mix. The magnitude of the crown is dependent on the depth of the rut and the type and extent of the traffic. See the figure "Reprofiling Rutted Wheelpaths with Micro Surfacing" on page 14 of Appendix B in ISSA A143 for rut depth and quantity of micro surfacing needed. Require a minimum of 24 hours under traffic before placing an additional lift on top of the filled ruts.*

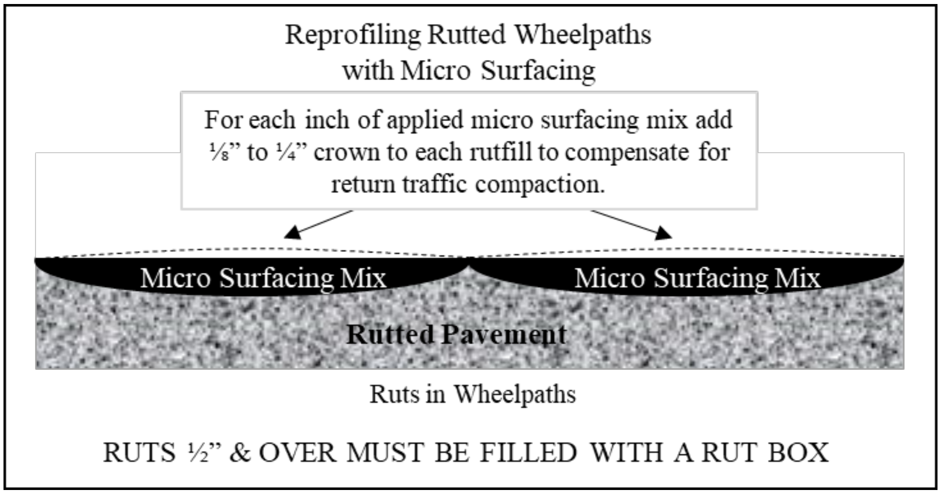


Figure 27 - Wheelpath Reprofiling Illustration

Rut filling is typically constructed with a Type III gradation. Deep ruts may require multiple lifts and the asphalt content may need to be adjusted to the low side of the allowable range unless the existing pavement condition is dry and absorptive. Asphalt contents that are higher than necessary may create stability problems.

Inspector's Note: *It is not uncommon for filled ruts to lack surface texture. This appearance is normal because the large aggregate is 100% embedded in the micro surfacing mixture. Uniform surface texture will be achieved after application of the full-width surface course.*

Attempting to fill ruts with a surface course is not recommended. Ruts not filled using a separate rut filling process will negatively affect surface course application rate and performance. A single rut of 6.4 mm (0.25 inch) or less deformation will increase the total average surface course application rate as the rut must be filled to the level of the existing pavement during the application process.

5. **Spreader Box**

There are many types and variations of spreader boxes but they all perform the same function, which is to spread the mixture in a uniform manner onto the pavement. Spreader boxes range from simple, light, non-adjustable units to large boxes equipped with augers, special runners, and hydraulic controls. Specialized boxes may be used for rut filling, special shoulder work, and variable width spreading. The spreader box choice depends on the slurry surfacing treatment type and specified application rate of the material. The contractor will provide the appropriate box for the project.

- Cleanliness is mandatory in a spreader box. The box must be cleaned at the end of every work period and may require cleaning (especially the rear rubber) during the work day if excessive buildup of mixture causes streaking in the finished surface.
- Ensure no loss of mixture from the spreader box. Side rubbers (when required) should be sized so that edges are kept neat. The primary strike-off rubber should provide a uniform application appearance across the full width of the mat and may be changed in thickness, width, and hardness to achieve desired results.
- The spreader box should pull smoothly and evenly without vibration. Machine speed should be relatively consistent. Excessive speed can cause the box to vibrate or jump leaving transverse ripple lines (washboarding) in the finished surface. If using a drag (typically a short length of burlap), excess speed may create a rippled and uneven mat. The most important factor in determining the allowable speed of application is the end result and quality of the treatment. Speed of application is affected by application rate, gradation of the aggregate, consistency of the mixture, and the existing surface texture.

Designer's Note: *While it is advantageous for all slurry surfacing system spreader boxes to contain augers, it is mandatory that micro surfacing spreader boxes contain them. Consideration may be given to the use of a variable width spreader box to minimize overlap and to assist the applicator when working on variable width pavements.*

Strike-Offs

One potential problem associated with slurry surfacing system treatments is drag marks. Drag marks are created when oversize aggregate particles, broken mix or road contaminants become lodged under the primary strike-off and are pulled along leaving a groove in the surface. Drag marks can be minimized by using a screening plant at the stockpile to eliminate oversized aggregate particles, proper cleaning of the spreader box to eliminate broken mix in the box and proper surface preparation to reduce road contaminants.

Figure 28 - Excessive Drag Marks Created by Poor Spreader Box Maintenance

There are two methods of repairing drag marks once the material has been applied on the pavement surface. The traditional method is to repair the groove with a squeegee.

Inspector's Note: The surface texture of the repaired drag mark should be as close as possible to the texture of the box-applied material.

A secondary strike-off (Figure 29) will also correct drag marks (Figure 30). It also improves the surface texture and surface cosmetics. The secondary strike-off mounts directly behind the primary strike-off and is in contact with the fresh mix. It removes most surface imperfections without requiring a person to remove them with a hand tool. The secondary strike-off does not remove the cause of the drag mark, so that still must be removed by hand. But it will correct the imperfections in the surface while the oversized aggregate is removed.

Figure 29 - Secondary Strike-Off on Variable Width Spreader Box (Spreader Box width is adjustable while applying mixture)

Figure 30 - Creation and Repair of a Drag Mark

Drag Types

A drag is often used to produce a uniformly textured mat. The drag may consist of canvas, burlap (Figure 31), carpet or other materials chosen to produce a particular texture. Instead of a fabric drag, a second rubber strike-off (Figure 30) may be used to achieve the desired surface texture. If a drag is used on the spreader box, the same material should be attached to the squeegees so that handwork duplicates the results produced with the spreader box.

Inspector's Note: *An improperly used drag can cause large stones to roll into positions where they are not properly imbedded in the mat. The drag length, height, and thickness should be adjusted for each specific aggregate gradation or slurry surfacing system. Drags need to be replaced when they become torn or inflexible. They should be kept in a completely flexible condition at all times so replacement may be needed multiple times a day.*

Figure 31 - Burlap Drag

6. Handwork

Many projects will include areas that are not accessible to the spreader box. These areas can be completed by the use of squeegees or asphalt lutes. If the spreader box uses a drag, one must also be used on the squeegees to obtain a matching texture. Handwork should be used minimally.

Figure 32 - Handwork

When handwork is being performed, wetting of the existing pavement (do not allow ponding/pooling of water) reduces surface tension and helps the squeegee operators to place and finish the mixture. The finished slurry surfacing should be uniform and closely resemble the appearance of the box applied material. Mix that has broken during handwork should be removed.

Inspector's Note: Handwork should be minimized. The longer the slurry surfacing mix is worked, the higher the potential for segregation. If the squeegee operator overworks the mix, the larger aggregate may separate from the fines and the mix may dehydrate. If the coarse aggregate does not embed in the mat properly, raveling is likely. Large areas requiring handwork should be applied in small sections, allowing sufficient time for placing and finishing the material without segregation.

F. Application Rates

Application rates may vary during the project due to changes in the existing pavement surface. The correct application rate of the treatment can have a significant impact on the success of the project. Excessive application rates may result in washboarding/rippling, displacement, and segregation. Inadequate application rates may cause excessive raveling and reduced service life. The three primary factors that influence application rate are aggregate gradation, existing pavement surface texture, and mixture consistency.

1. Aggregate Gradation

For aggregate on the coarse side of the gradation specification, application rates should be higher. Otherwise, the largest aggregate particles will not adequately embed in the slurry surfacing mixture. Insufficient embedment may cause drag marks when larger stones are caught by the strike-off rubber. Raveling may result from insufficient embedment, as well. Conversely, for aggregate on the finer side of the gradation specification, application rates should be lower to avoid flushing of the surface.

By design, slurry seals are applied in a layer equal to the largest stone in the gradation. Slurry seal applied at less than, or in excess of, the recommended application rate, or in multiple layers, may create an unstable treatment leading to raveling, flushing, rutting, premature wear, or washboarding.

Applications requiring multi-stone depth thickness must use micro surfacing (See Figure 33). Micro surfacing applied as a surface treatment will vary in thickness and weight per unit area when the surface texture of the pavement changes. Typical application rates for Type II and Type III gradations can be found in A143 in Section 11.2. The exact rate will depend on the aggregate gradation and the texture of the existing surface.

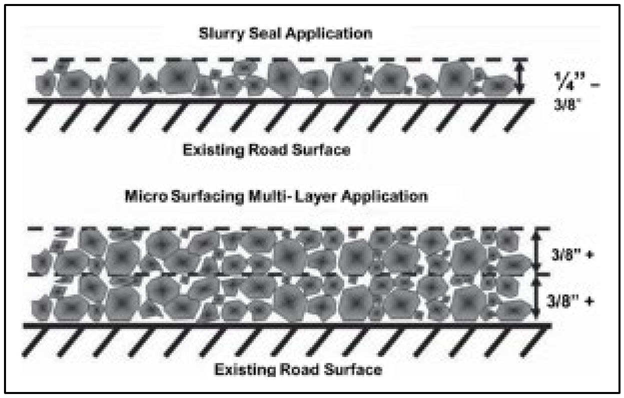


Figure 33 - Aggregate Orientation – Slurry Seal vs Micro Surfacing

Designer's Note: *The application rate should be specified in the plans and should take into consideration aggregate gradation, existing surface texture and proven past performance of the mix. Additionally, a tolerance of approximately ± two pounds should be established.*

2. Existing Surface Texture

The existing surface void content will directly affect the application rate of the slurry surfacing system. 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, additional material beyond the desired application rate is not needed. (See Section IX.C, page 88, Excessively Rich, Flushed, or Bleeding Asphalt Surfaces for more guidance on applications over smooth or flushed surfaces.)

Figure 34 - Fine Surface Texture

Figure 35 - Coarse Surface Texture

3. Mixture Consistency

The consistency of a slurry surfacing system mixture is important. If the consistency is too fluid the mixture may segregate as larger aggregate particles sink and emulsified asphalt and fines float to the surface. This may lead to lower application rates. If the consistency is too dry, higher application rates may result due to increased build-up of the mixture.

<u>Inspector's Note:</u> Operators may be tempted to add excessive water, especially when a wide pass is being applied. The use of augers in the spreader box can greatly reduce the need to add additional water. Slurry systems containing excess water may have:

- *free liquids present in the spreader box*
- *a flushed appearance*
- *a segregated appearance*
- *liquids running from the edge of the mat after application*

Figure 36 - Poor Mixture Consistency – Excess Total Liquids

G. Inspection Points

Oversight of quality during construction is a shared responsibility between the agency and the contractor and is important in achieving a successful project. Working together, potential problems and challenges should be identified and resolved as they arise during the course of the project. Areas requiring special attention are discussed below.

1. Longitudinal Joints

No excess buildup, uncovered areas, or unsightly appearance should be permitted on longitudinal or transverse joints. The contractor should provide suitable width application equipment to produce a minimum number of longitudinal joints throughout the project.

<u>Designer's Note:</u> High quality longitudinal joints should be straight, on lane lines, and uniformly follow the traffic lane on curves. They may be constructed as an overlap or butt joint. If overlapped they must correspond to the lane lines and should not exceed 76 mm (3 inch) in width. Joints should be smooth and neat in appearance, avoiding excessive build-up or uncovered areas.

Figure 37 - Construction of a Good Longitudinal Joint

Figure 38 - Acceptable Longitudinal Joint

Figure 39 - Unacceptable Longitudinal Joint

<u>Inspector's Note:</u> Longitudinal joints should be smooth. There should be no more than a 6.4 mm (0.25 inch) difference in elevation when measured by placing a 3 m (10 ft) straight edge over the joint and measuring the elevation difference.

2. Transverse Joints

Each time the application equipment stops, a transverse joint must be constructed when paving resumes. Transverse joints should be smooth, neat in appearance, and handwork should be kept to a minimum. Excessive buildup or uncovered areas should not be permitted. When possible, transverse joints should be constructed as a butt joint rather than an overlap joint. Roofing felt may be used by the contractor in constructing acceptable transverse joints.

Figure 40 - Unacceptable Transverse Joint

Figure 41 - Unacceptable Transverse Joint

<u>Inspector's Note:</u> When a stop is required, the spreader box should contain mix across its full width. A line in the mixture, perpendicular to the edge of the road, should be cut with a square point shovel. This line should be located where the application rate is uniform and all material removed beyond this point in preparation for the subsequent pull.

3. Edge Lines

The edge of the spreader box should produce a very straight and clean edge line and correspond to the original edge of the pavement. Normally the existing paint line at the edge of the pavement is adequate for the operator to use as a guide mark. If the operator has difficulty in achieving a straight edge line, a string line or pilot line should be used as a guide. All transitional areas will need a string line or pilot line to produce the desired results.

Figure 42 - Use of Existing, Straight Pavement Edge or Shoulder Line

Figure 43 - Use of Pilot Line

<u>Inspector's Note:</u> The mixture may flow and run off onto the shoulder if the spreader box is poorly maintained, set up improperly, or if the mixture contains too much liquid. If this occurs, the operation should be stopped until the issue is corrected.

4. Final Surface Texture

Slurry surfacing systems designed and properly installed according to ISSA Recommended Guidelines should yield a consistent surface texture throughout the project. These systems can be applied to result in a wide range of final surface textures depending on a variety of factors (see the list below). When applied properly, an aggressive surface texture can provide a high friction surface for the duration of the life of the application. Figure 44 shows a freshly constructed application with a uniform surface texture and Figure 45 shows a more magnified view.

Figure 44 - Good Surface Texture Uniformity

Figure 45 - Magnified View of High Friction Surface Texture

Factors that influence the final surface texture are:

- Existing pavement surface texture
- Mix consistency
- Adherence to the JMF
- Type of screed rubber
- Spreader box operation and maintenance
- Use and orientation of a secondary strike-off
- Use of fabric drags
- Application rate
- Speed of application machine (too fast may cause washboarding)
- Pre-maturely opening to traffic
- Aggregate gradation, and
- Rolling (if required in airports and parking lots)

<u>Inspector's Note:</u> Properly applied slurry surfacing system treatments will result in adequate stone embedment and achieve the desired surface texture and optimum application rate. Treatments placed too thin may have inadequate embedment which will adversely affect long-term performance.

5. Ride Quality

Slurry surfacing system treatments generally follow the existing road surface profile and do not significantly change the pavement's ride quality. However, micro surfacing may correct minor surface irregularities, thus improving the ride quality to a moderate extent.

6. Early Traffic Damage

Slurry surfacing system treatments must build sufficient cohesion to resist abrasion due to traffic. Minimal raveling is not unexpected when initially opened to traffic, especially in areas where handwork has been done or in cool weather. If this condition occurs, loose aggregate should be removed via sweeping, or vacuuming, to prevent additional damage.

Figure 46 - Damage Due to Premature Traffic – Requires Repair

<u>Inspector's Note:</u> It is the contractor's responsibility to determine the appropriate timing for return to traffic, assuming responsibility for any damage after that point.

Some slurry surfacing systems may be tender in their infancy. Minor abrasion and tearing may occur under high torque in the early weeks after placement. High pavement and ambient temperatures may compound these occurrences.

Figure 47 - Minor Surface Scuffing/Power Steering Marks

Inspector's Note: *Power steering turn marks are possible when slurry surfacing system treatments are new and pavement temperatures are high. Confined areas requiring tight turns may result in abrasion. Although the marks may mend with traffic, if they are considered to be excessive (abraded to underlying pavement), the contractor should repair them.*

7. **Application Rate Verification**
The overall performance of the slurry surfacing system is directly related to the proper application rate of the material. It is recommended that the application rate be verified a minimum of four (4) times per day. The factors determined during the calibration process are necessary for the verification of the application rate. In most cases, application rates are based upon pounds of dry aggregate per square yard.

Inspector's Note: *The inspector should monitor the project daily to track the amount of materials placed. The calibration factors from each piece of application equipment are used to determine the total amount of materials applied. The weight of the dry materials divided by the area of the treatment gives the application rate.*

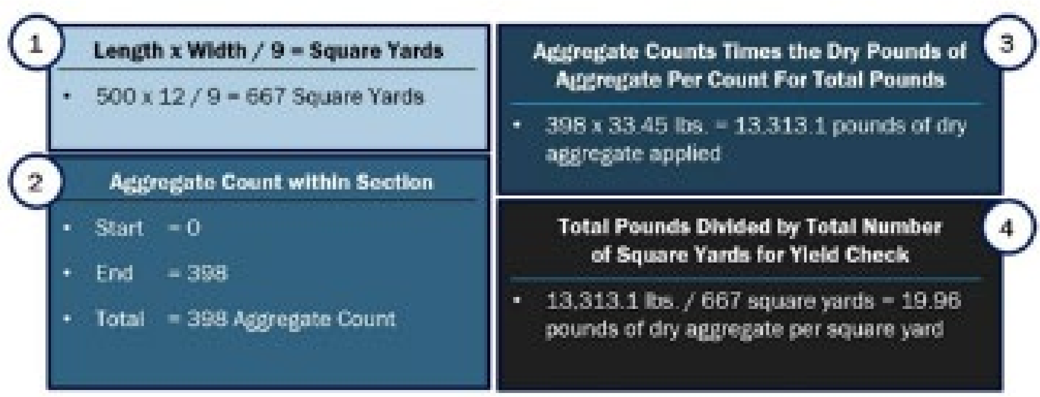


Figure 48 - Example of Rate Application Verification

VII. CONTRACT ADMINISTRATION

A. Pre-Construction Meeting

The BAR should arrange for and conduct a pre-construction meeting with the prime contractor. BARs may include a project manager, project engineer, inspector, material testing technician, and others as deemed necessary. A representative of the prime contractor and each sub-contractor should attend. Detailed minutes should be recorded by the project engineer or designee and distributed to all parties in attendance. Although the pre-construction meeting is focused on administrative and operational considerations, the greatest value of the meeting is achieved by all parties discussing, clarifying, and fully understanding all aspects of the contract.

Designer's Note: *A primary objective for this meeting is to designate the responsible parties for the project. BAR and contractor representatives need to communicate daily to ensure safe and efficient progression of the work.*

Pre-Construction Meeting Objectives
1. Introduce team members and establish the project lines of communication and authority.
2. Review the project schedule prepared by the contractor.
3. Coordinate the submission of the mix design, samples and other required documents.
4. Address questions regarding contract specifications that may require clarification or decisions from the BAR.
5. Review safety procedures and special project requirements.
6. Review the traffic control plan, public notification, and procedures to notify public services such as police, fire, ambulance, trash pickup, transit service, etc.
7. Establish punch list timing and project acceptance procedures.
8. Designate BAR responsibilities for daily acceptance of material quantities and final project acceptance.
9. Establish procedures and requirements for progress payments.
10. Agree on locations for temporary facilities, stockpiles, and staging areas.
11. Discuss sources of water and specific requirements for metering.
12. Identify material testing requirements and frequency, including contractor QC plan, if required.
13. Agree on timing of early and final surface preparation (See Sections VI.B.1-2, pages 38-43, Surface Preparation).
14. Submit relevant Safety Data Sheets (SDSs).
15. Agree on application timing of temporary and permanent pavement markings.

B. Job Site Safety

Safety is the responsibility of every person on the project. The BAR and the contractor must both be vigilant to ensure safe working conditions and that safe work practices are followed at all times. Both the BAR and the contractor set the tone and should set a good example in all aspects of safety including the use of Personal Protective Equipment (PPE).

Designer's Note: It is also recommended that the contractor submit their company's safety policy and project specific safety plans prior to project start up.

C. On-Site Sampling and Testing of Materials

During the process of producing, hauling, and stockpiling materials, good quality control procedures require tests to:

- Ensure that only material consistent with the JMF is used in the slurry surfacing system
- Provide a permanent record as verification that the materials meet project specifications.

Proper sampling techniques must be followed for all materials. Material sampling techniques shall follow ASTM D75 or AASHTO T2: Standard Practice for Sampling Aggregates and ASTM D140 or ASHTO T40: Standard Practice for Sampling Asphalt Materials.

Inspector's Note: The best place to sample emulsified asphalts in the field is from the sample valve of the tanker trailer or the storage tank.

Designer's Note: All materials used in the application of slurry surfacing system treatments must have first been tested in a laboratory to establish the mix design. Testing of project raw materials to ensure their similarity to those properties reported in the mix design should be conducted at the frequency appearing in Table 3.

Test	Frequency
1. ASTM C117 or AASHTO T 11: Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing and ASTM C136 or AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregates. Ensures aggregate is within the stockpile tolerance of the mix design gradation.	One test per 500 tons of aggregate unless a problem arises requiring more frequent testing.
2. ASTM D6933 or AASHTO T59: Standard Test Method for Oversized Particles in Emulsified Asphalts (Sieve Test). Ensures emulsified asphalt is free of oversized asphalt particles.	One test per day or one test for each transport load delivered to the project site. A Certificate of Analysis (COA) for each load would also be acceptable.
3. Ensure mineral fillers are the same type as designated in the mix design.	Once prior to starting the project and again if the source changes.

Table 3 - Test Frequencies

<u>Inspector's Note:</u> It is the inspector's responsibility to verify that test results indicate that materials delivered to the job site are consistent with the materials listed in the mix design.

The most common practice to determine individual material quantities and application rate is to obtain data from the proportioning devices on the previously calibrated slurry surfacing application equipment. Due to the challenges associated with sampling the mixture directly from the application equipment, a much less common practice is to take representative samples and then to run the residual asphalt content according to ASTM D2172, Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures and AASHTO T 164, Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA). Another test to determine residual asphalt content under consideration but not yet validated for slurry surfacing systems is AASHTO T308, Standard Method of Test for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method. The BAR must notify the contractor immediately if any test fails to meet specifications.

<u>Inspector's Note:</u> The materials and mixture tests conducted during construction normally address whether the materials being placed meet the requirements established in the JMF approved prior to beginning construction. Any tests run from field samples should be processed in the same manner as the laboratory design tests. All acceptance tests must be completed according to the schedule agreed upon during the pre-construction meeting and/or as written in the project plans.

D. Construction Phase

Quality assurance during construction is a responsibility shared by the project inspector and the contractor. Elements of construction that should periodically be checked for compliance with the project specifications appear below:

Quality Assurance Guide for Slurry Surfacing System Construction
1. Traffic control, signage, etc. are consistent with the "Manual on Uniform Traffic Control Devices" (MUTCD) and the project-specific traffic control plan,
2. Pavement surfaces are clean and prepared to receive treatment,
3. Air and pavement temperatures are suitable during and after treatment application,
4. Structures and castings are protected prior to treatment application and their locations are properly referenced,
5. On-site sampling and materials' acceptance testing is completed according to the frequency according to the schedule agreed upon during the pre-construction meeting and/or as written in the project plans,
6. Application rates are consistent with project requirements.

E. Opening to Traffic

Opening slurry surfacing system applications to traffic is a function of the time it takes the emulsified asphalt to break and the mixture to cure. The air/pavement temperatures and humidity affect the curing time. Generally, as the temperature increases and the humidity decreases, it takes less time for the emulsified asphalt to break and the mixture to expel the water. Conversely, cooler and/or more humid conditions, as well as shaded areas, may require longer curing times before opening to traffic.

Micro surfacing can normally handle straight-rolling traffic approximately one hour, or less, after placement without damage. Additional curing time may be required when applying in areas with stop and go and/or turning traffic, in residential areas, or in unusually hot or cool weather. It is ultimately the contractor's responsibility to determine the appropriate time for opening the freshly applied material to traffic.

Inspector's Note: It is important to note that the contractor is responsible for protecting the newly applied slurry surfacing system from damage and that opening to traffic does not constitute acceptance of the work. Therefore, it is better to allow additional curing time if there is any doubt about the materials' ability to support traffic without damaging the newly placed surface.

F. Methods of Measurement and Payment

Accuracy in quantity measurements is an essential part of inspection and agreement on the quantities requires a coordinated effort between the inspector and the contractor. The contract will specify the methods of measurement and payment for the project. Methods vary among agencies but usually fall into one of the following categories:

Option 1. Unit Area (square feet, square yard or square meter)

Measurement and payment by the unit area:

1. Calculate the surface area of all treated pavements.

Option 2. Ton of Mix (metric)

Measurement and payment by the composite ton is usually specified to include the dry aggregate, mineral filler and emulsified asphalt.

1. Determine the tons of dry aggregate applied daily by one of the following methods:
    - Use calibration factors to calculate dry aggregate used, or
    - Use certified belt scales to weigh the aggregate. Deduct the moisture in the aggregate to determine the weight of the dry aggregate.
2. Determine the tons of mineral filler used daily by one of the following methods:
    - Use the calibration factor to calculate the mineral filler used, or
    - Count the number of bags used.
3. Determine the gallons/liter of emulsified asphalt daily using the calibration factor.
4. Add 1, 2 and 3 for total tons of mix.

Option 3. Weight (Ton/Metric Ton) of Dry Aggregate and Volume (Gallon/Liter) of Emulsified Asphalt

Measurement and payment by the ton of dry aggregate and gallon/liter or ton of emulsified asphalt requires the calculations outlined in Option 2.

1. Determine the tons of dry aggregate applied daily by one of the following methods:
    - Use calibration factors to calculate dry aggregate used, or
    - Use certified belt scales to weigh the aggregate. Deduct the moisture in the aggregate to determine the weight of the dry aggregate.
2. The mineral filler will be considered part of the aggregate. Determine the tons of mineral filler used daily by one of the following methods:
    - Use the calibration factor to calculate the mineral filler used, or
    - Count the number of bags used.
3. Add 1 and 2 for total tons of dry aggregate.
4. Determine the gallons/liter of emulsified asphalt daily using the calibration factor.

Inspector's Note: If the inspector would like to cross-check quantities calculated using the calibration factors, material usage amounts may be approximated by adding delivery ticket totals for each material minus remaining inventory.

Designer's Note: Normally, costs for notification, surface cleaning, structure and casting protection, and water supply are incidental costs and are included in the contract price for the associated line items. Other costs, such as mobilization, traffic control, pavement marking removal and replacement, and tack coat (if required) are examples of items that should have dedicated line items for payment.

G. Project Close Out

The inspector and contractor should cooperate to accomplish the following objectives:

- Assembling the required documentation and submittals required by the contract,
- Completing all the remaining punch list items,
- Performing a final inspection, and
- Agreeing on final measurement and payment quantities.

VIII. TROUBLESHOOTING SLURRY SURFACING SYSTEMS

These conditions may be experienced at times with all slurry surfacing systems, unless otherwise noted.

A. Non-Uniform Color

Condition: The finished surface may exhibit color variations. These color variations may not be discernable until the next day. They will usually disappear as the slurry surfacing is exposed to traffic and elevated temperatures. Although these issues are predominantly aesthetic and should not affect long-term performance, fog-sealing may be appropriate when the final color is not acceptable.

Figure 49 - Non-Uniform Color after Curing

Possible Causes:

Application Equipment:

- Not accurately calibrated
- Mechanical issues affecting proportioning

Prevention: Application equipment should be accurately calibrated and in good working condition. If multiple pieces of equipment are used on a project, they should be set up to produce an identical mixture within the JMF.

Possible Causes:

Environmental Conditions:

- Rain on recently applied material
- Cool temperatures or shaded areas
- Variations in humidity

Prevention: Slurry surfacing systems should not be applied if the pavement or air temperature is below 10°C (50°F) and falling or when rain is imminent, but may be applied when both pavement and air temperatures are above 7°C (45°F) and rising.

Inspector's Note: When a properly proportioned slurry surfacing mixture is discolored due to environmental conditions, fog sealing may be appropriate for restoring aesthetic value. One part slurry surfacing emulsified asphalt diluted with three parts water should be applied at a 0.22-0.45 l/m2 (0.05-0.10 gal/yd2) rate.

Possible Cause:

Emulsified Asphalt/JMF:

- High emulsifier dosage
- Additive/mineral filler dosage
- High water usage

Prevention:

Overly stable mixtures may lead to delayed curing and cause color variations, requiring reformulation of the emulsified asphalt, or adjustments to the additive and/or mineral filler dosages. Adding excessive water to the mixture may cause the emulsified asphalt to migrate to the surface, giving a slick, black appearance. Also, if water is applied from a hand-held hose onto the placed slurry surfacing, the emulsified asphalt may wash off the surface and expose the color of the aggregate.

Inspector's Note: Although discouraged, adding a minimal amount of water with a hand-held hose either into the spreader box or to the freshly applied slurry surfacing may be appropriate at times.

B. Raveling

Condition: Raveling occurs when particles of aggregate dislodge from the finished surface once opened to traffic.

Figure 50 - Raveling

Possible Cause:

- Insufficient asphalt binder
- Poor quality raw materials
- Insufficient fines for filling the voids between larger aggregate particles

- Application rate not allowing for the embedment of larger aggregate particles
- Cooler temperatures resulting in delayed curing
- Premature opening to traffic
- Rain exposure before achieving final cure

Prevention:
- Verify adherence to the JMF.
- Confirm that raw material properties adhere to specifications.
- Verify that the mixture is being applied at the proper application rate.
- Ensure that application temperatures are adequate.
- Do not release the traffic prematurely.
- Do not apply if rain is imminent.

Inspector's Note: *Slurry surfacing systems may shed some aggregate during the first few days of traffic, but it should be minimal. The phenomenon is less likely to occur in areas applied with the spreader box than in areas that were hand-worked or that are lightly traveled.*

C. Flushing

Condition: Flushing occurs when the emulsified asphalt in the slurry surfacing system migrates to the surface, giving a slick, black appearance. (Bleeding of the existing surface prior to slurry surfacing, which is an entirely different phenomenon, is addressed in Section IX.C, page 88, Excessively Rich, Flushed, or Bleeding Asphalt Surfaces.)

Figure 51 - Flushing

Possible Causes:
- Mixture containing too much water or emulsified asphalt
- Excessive overlapping of passes
- Excessively heavy application rate

Prevention:
- Verify adherence to the JMF and the calibration of the application equipment.
- Minimize overlap of passes.
- Use the correct application rate for the existing surface condition.

Designer's Note: *The application rate should be specified based on traffic volume, existing surface texture, available aggregate supply and the expectations of the treatment. Specify at the higher end of the range for high traffic roads to provide more of a wearing surface or for very rough pavements, as the voids will require more material. Specify at the lower end of the range for existing pavements with a consistent profile, or a smooth surface. The application rate of slurry surfacing systems is always specified in kg/m2 or lb/yd2, as the irregular surface finish does not allow for an accurate thickness measurement.*

D. Lack of Uniformity of Mixture at the Beginning or End of Passes

Condition: Mix consistency is not uniform compared to the rest of the pull.

Figure 52 - Lack of Surface Texture Uniformity

Figure 53 - Lack of Uniformity at the Beginning/End of Passes

Possible Causes: Improper equipment auto-sequencing or operator/crew error.

Prevention: Although complete prevention may not be possible, the magnitude of the issues can be minimized by setting auto-sequencing devices correctly and training the crew properly.

Inspector's Note: *Excess and/or unbound material should be removed. When complete, a full width pass of spreader box applied mixture should be placed beginning and ending 10-15 feet on either side of the original joint.*

E. Breaking Too Fast

Condition: The mixture breaks in the pugmill, spreader box or prior to completion of any necessary handwork.

Possible Causes:

- High temperature of emulsified asphalt
- High ambient temperature
- Elevated road surface temperature
- High or low mineral filler
- Poorly formulated emulsified asphalt
- Freshly crushed/reactive aggregate
- High fines content in the aggregate
- Inaccurate calibration

Prevention: Ensure that the application equipment is calibrated, that the mixture components are consistent with those used in the mix design and that all materials are optimized for the application conditions.

Inspector's Note: Emulsified asphalt is typically manufactured at temperatures ranging from 77ºC to 88ºC (170ºF to 190ºF) and is usually delivered to the job site at temperatures from ambient to 49ºC (120ºF). On cool days, the extra heat (over 38ºC or 100ºF) helps promote set, but on hot days this additional heat may present problems.

The effect of road temperature will vary depending on the emulsified asphalt and aggregate system being used. Hot surface temperatures accelerate set and reduce available mixing time. Wetting the surface with water from spray bars and hand hoses helps keep pavement temperatures down. Slightly less mixture in the spreader box cuts down on the time in the box.

F. Breaking Too Slow

Condition: The mixture breaks too slow, causing delays in opening to traffic

Possible Causes:

- Low ambient temperatures
- High humidity
- Poorly formulated emulsified asphalt
- Shade or cloudy conditions
- Inaccurate calibration

Prevention: Suspend operations if temperatures are not within the recommended application range. Ensure that the application equipment is calibrated, that the mixture components are consistent with those used in the mix design and that all materials are optimized for the application conditions. In shaded areas, when possible, place the mixture early in the day to provide extra time to facilitate breaking and curing. In some cases, it may be necessary to stop work in these areas earlier in the day to allow time for curing.

G. Unsatisfactory Handwork

Condition: In areas where handwork was required, the finished slurry surfacing shows uneven application of material, non-uniform surface appearance (streaks and drag marks) and excessive loose aggregate.

Figure 54 - Unsatisfactory Handwork

Possible Causes: The quality of the finished product will be directly proportional to the level of experience of the handwork crew. High temperatures may accelerate the break and reduce available time for handwork. In large areas not accessible to the application equipment, the number of workers may be insufficient to spread the mix before it breaks.

Prevention: An adequate number of properly trained crew members is essential for quality handwork. Whenever possible, perform handwork early in the day when cooler ambient and pavement temperatures allow extra time for the slurry surfacing mixture to be worked before the set begins. Using a set control additive and/or wetting the existing pavement helps the handwork personnel to place and finish the mixture. Large areas requiring handwork should be applied in multiple small sections to allow enough time to properly spread and finish the surface before the mixture breaks. The finished slurry surfacing should be uniform and closely resemble the appearance of the box applied material. Mix that has broken during handwork should be removed.

H. Tire Marks and Surface Abrasion (Scuffing)

Condition: Unsightly tire marks appear on a newly placed slurry surfacing.

Figure 55 - Power Steering Marks

Possible Causes: In its infancy, slurry surfacing may be susceptible to surface scuffing due to stationary use of vehicle power steering. Reoccurrence of this issue may appear during periods of hot, humid weather. Traffic may heal minimally abraded areas, although more severe surface blemishes might require repair.

Prevention:

- Use a harder base asphalt,
- Specify a polymer-modified emulsified asphalt,
- Roll the new slurry surfacing with a pneumatic tire roller (for parking lots and airfields),

- Parking lot application of slurry surfacing during the cooler months of the year is preferred to allow the mixture to cure prior to the next hot season

<u>Designer's Note:</u> Consider specifying a higher softening point on the emulsified asphalt residue, rolling parking lots and airfields with a pneumatic tire roller, and scheduling parking lot applications until cooler weather.

I. Constructability and Performance Issues over Crack Treatments

<u>Condition:</u> Excessively thick crack treatments may cause construction and performance issues for slurry surfacing.

Figure 56 - Excessive Crack Sealant Application

<u>Possible Causes:</u> Excessively thick crack sealants may snag on the spreader box or application equipment tires (see Figure 56). Crack treatments that have been sprayed with a tack coat may adhere and be dislodged by the tires of the application equipment.

<u>Prevention:</u> Use the appropriate sealant for the project climate and avoid overfilling cracks. The thickness of the sealant on the surface of an overband configuration should be minimized and as flush to the pavement surface as possible. Allow the crack treatment sufficient cure time prior to placing the slurry surfacing. The use of spray bars on the application equipment may minimize constructability issues.

J. Delamination

<u>Condition:</u> The slurry surfacing system delaminates from the underlying pavement.

Figure 57 - Delamination
(not likely a bonding issue, more likely caused by water migration from the subgrade)

Possible Causes: There are multiple issues that may lead to delamination of slurry surfacing systems. Any surface contaminant (including but not limited to vegetation, dirt, loose aggregate, hydraulic oil, diesel, and animal remains) will cause adhesion problems. Slurry surfacing systems applied over coal tar seal coats may have poor adhesion. Improper drainage may trap water between the existing pavement and the slurry surfacing and can accelerate stripping which may lead to delamination.

Prevention: Slurry surfacing systems should not be placed over coal tar seal coats. Tack coat should be applied to concrete surfaces before application. Detailed information on tack coat can be found in Section VI.E.2, page 48, Tack Coat. Most delamination can be avoided by properly preparing the existing surface as described in Section VI.B.2, page 39, Surface Cleaning.

K. Rain on Freshly Applied Slurry Surfacing

Condition: Discoloration caused by rainfall prior to curing of the slurry surfacing.

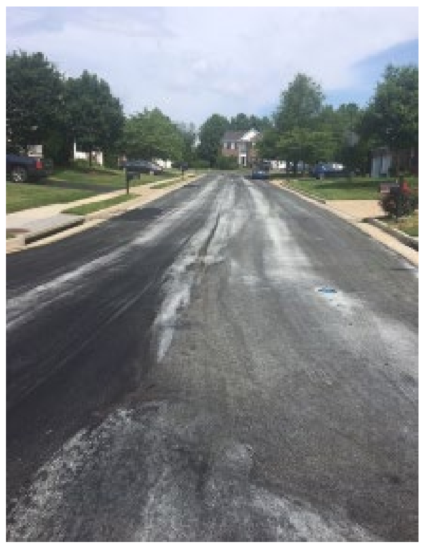


Figure 58 - Appearance Immediately After Rainfall

Figure 59 - Appearance Two Weeks Later

Possible Causes: Rainfall occurred before sufficient curing of the slurry surfacing.

Prevention: Routine observation of weather radar is an important first step in preventing rain on freshly applied slurry surfacing. Weather radar can be monitored from the project site or from a remote location.

Inspector's Note: The extent of the damage experienced will determine the remedial efforts required.

- *Light rain may require a road closure until the slurry surfacing can support normal traffic before reopening.*
- *Moderate rain may wash the emulsified asphalt from the surface of the mixture. A road closure is required, and the slurry surfacing should be allowed to cure and dry. If loose aggregate is present, it should be swept prior to opening to traffic. After exposure to normal traffic, damage determined to be unacceptable should be corrected with a new application of slurry surfacing over the remaining material.*
- *Heavy rain may cause a major loss of emulsified asphalt. A road closure is required until loose material removal can be accomplished by sweeping. After exposure to normal traffic, damage determined to be unacceptable should be corrected with a new application of slurry surfacing over the remaining material.*

L. Skinning

Condition: The mixture breaks on the surface, trapping remaining moisture inside and extending the cure time.

Possible Causes: This is not common, but may occur in high heat, in high or low humidity, and generally when the system is too fast for conditions. Evaporation of water from the surface can become so rapid that a blanketing film or "skin" is formed. Lack of mineral filler in the mixture may also lead to the issue.

Prevention: High ambient temperatures contribute to accelerating system break and set. Pre-wetting the surface immediately prior to application helps reduce pavement temperatures. Guidance can be referenced in Section VI.E.2, page 47, Pavement Pre-Wetting. In severe cases, it may be necessary to work earlier in the day before the temperature rises. If it is determined that the mixture lacks mineral filler, the proper operation of the fines feeder should be verified.

M. False Slurry

Condition: A false slurry occurs when the emulsified asphalt prematurely breaks on the fines portion of the aggregate during the mixing process. Because of this, the emulsified asphalt is unable to create a uniform film on larger aggregate particles leading to unacceptable mixture cohesion.

Possible Causes: After breaking on the fines, the emulsified asphalt releases emulsifier into the mixture, extending mix time and making a false slurry difficult to recognize. Excessive foaming, gray color, or an excessive amount of large, uncoated aggregate can be signs of the issue.

Prevention: Check calibration of placement machine(s) and confirm compliance of materials with the mix design and JMF.

N. Tire Pull-Off

<u>Condition:</u> In situations where application equipment must drive over freshly applied slurry surfacing (for example, cul-de-sacs or narrow roadways), tires may pick up material. Large patches of mixture are then deposited on pavement yet to be surfaced.

<u>Possible Cause:</u> Application equipment is driven on fresh slurry surfacing.

<u>Prevention:</u> The operator may use the hand hose or machine spray bars to wet the tires and the freshly applied material to minimize material pick-up. Excessive material build-up on tires, as well as material dropped on the pavement, should be removed.

<u>Inspector's Note:</u> This situation is not common but may occur in the areas described above.

O. Slurry Surfacing Mixture on Concrete Gutters and Valleys

<u>Condition:</u> Slurry surfacing is spilled or tracked onto concrete gutters and valleys.

Figure 60 - Poor Workmanship Resulting in Slurry Surfacing on Gutter/Driveway

Figure 61 - Mix on Curb/Driveway

Possible Causes: Slurry surfacing system treatments containing an excessive amount of liquids tend to have unacceptable consistency that makes achieving a clean, crisp edge line along the concrete gutter difficult. Line drivers that have difficulties following the edge line or curb line contribute to this problem. Application equipment leaving the project with emulsified asphalt or mix on their tires can leave tracks across concrete gutters or valleys.

Prevention: Accurate equipment calibration, adherence to the JMF and maintaining the proper mix consistency will eliminate/minimize slurry surfacing mixture on concrete gutters and valleys. When applying slurry surfacing adjacent to a concrete gutter or valley, a skillful driver can simplify the operator's task by moving the spreader box laterally as required. When accompanied with proper spreader box set up and a stable homogeneous mixture, it can produce results such as those seen in Figure 62.

Figure 62 - Successful Results from Adherence to Best Practices

Inspector's Note: Slurry surfacing mixture spilled or tracked onto concrete should receive prompt attention. The contractor should remove excess material from the concrete. Dusting with cement or making a fine cement slurry mix and brushing it on the affected area can be effective for small areas. In extreme cases, power washing may be necessary.

P. Washboarding

Condition: Transverse corrugations are present in the finished slurry surfacing material.

Figure 63 - Washboarding

Possible Causes: Fabric drag installed too high allowing for "bouncing", excessive forward speed, ski wear, or improper spreader box set-up and maintenance can all lead to washboarding.

Prevention: If fabric drags are used they should be mounted in close proximity to the existing pavement so as to eliminate bouncing. The machine speed should be relatively consistent. The speed of application is affected by the application rate, gradation of aggregate, consistency of the mixture, and existing surface texture. The most important factor in determining the allowable speed of application is the end result and quality of the treatment. Proper spreader box set-up and maintenance will ensure that the box pulls smoothly and evenly without vibration.

Inspector's Note: The importance of preventing washboarding cannot be overstated. If it does occur, resurfacing with the same material will not completely correct the issue but it may minimize its extent.

Q. Premature Breaking of the Mix

Condition: The slurry surfacing mixture breaks too quickly causing material build-up in the spreader box. The resulting broken mixture will not bond to the pavement surface.

Possible Causes: Any of the following may lead to the system breaking too quickly:

- Inaccurate application equipment calibration
- Incorrect loading of mineral filler and/or untested changes to the JMF
- Improperly formulated emulsified asphalt
- Non-potable water
- Hot emulsified asphalt
- Spreader box without augers
- Lack of additive
- Freshly crushed aggregate
- Changes in gradation or sand equivalent value
- Reactivity of the aggregate fines
- Extreme heat

Prevention:

- Verify the calibration of application equipment.
- Confirm compliance of materials with the mix design and JMF.
- Ensure that the emulsified asphalt is properly formulated for the job aggregate and conditions.
- Use potable water free from harmful salts and contaminants.
- Ideally, use emulsified asphalt at temperatures from ambient to 49ºC (120ºF).
- Maintain constant movement of the slurry surfacing mixture, preferably using spreader boxes equipped with augers.
- Allow the operator to control the break time through the use of additive capabilities on the application equipment.
- Work closely with aggregate suppliers to ensure that consistent, seasoned material matching the mix design is delivered to the jobsite.
- Apply material early in the day.

R. Surface Irregularities

Condition: The finished surface has scratches, drag marks, tears, or other surface irregularities.

Figure 64 - Excessive Drag Marks and Scratches

Possible Causes:

- High/Low application rate,
- Oversized aggregate (not using scalping screen),
- Spreader box cleanliness
- Debris on existing pavement surface.

Prevention:

- Ensure the proper application rate for the aggregate gradation used.
- Use a scalping screen (properly sized) to remove oversized aggregate before it enters the application equipment.
- Keep the spreader box and strike-off rubbers free of broken slurry surfacing materials by cleaning as needed each time the application equipment stops.
- Use a secondary strike-off to eliminate drag marks and provide a uniform surface texture.
- Properly clean and prepare the existing surface according to Section VI.B.2, page 39, Surface Cleaning.

Inspector's Note: An experienced crew can repair small tears, damaged areas, and drag marks before the emulsified asphalt breaks using hand squeegees and drag mops. They can also make hand repairs between double strike-offs so that the marks cannot be seen after the second strike-off passes over it. Small, isolated areas can be addressed provided they are squared off and have an appearance consistent with the rest of the slurry surfacing as excessive repairs may lead to a non-uniform appearance. Larger repairs should be full width and completed using the application equipment and spreader box to match the existing lane width. The repairs need to be long enough to cover the damaged are.

S. Poorly Constructed Longitudinal Joints

Condition: Longitudinal joints are constructed with one, or more, of the following conditions:

- Crooked
- Excessive overlap

- Excessive build-up
- Unsightly appearance
- Uncovered areas

Figure 65 - Unacceptable Longitudinal Joint

<u>Possible Causes:</u> Although pavement geometry may contribute to difficulty in placing longitudinal joints, these conditions are typically related to poor construction practices.

- Lack of a pilot line to guide driver
- Improper box width
- Improper box operation
- Poor workmanship
- Inadequate box width for pavement

<u>Prevention:</u> Proper planning of the product application process by the contractor will ensure proper joint placement and construction.

- Use pilot lines as a guide for alignment in areas where necessary.
- Place longitudinal joints on lane lines utilizing a box width equal to the lane width, when possible.
- Operate the spreader box so that the joint has no more than 6.4 mm (0.25 inch) difference. in elevation when measured by placing a 3 meter (10 foot) straight edge over the joint and measuring the elevation difference.
- Keep longitudinal joint overlap to less than 76.2 mm (3 inches) unless the width of the pavement requires wider overlaps to keep the spreader box on the pavement surface.
- Eliminate gaps or uncovered areas at the longitudinal joint.
- Apply partial width passes only when necessary and not for the last pass of any paved area.

<u>Inspector's Note:</u> During application, squeegees or drag mops are effective for eliminating small gaps and slight overlaps between adjacent lanes. If the longitudinal joints are not neat and aligned in a uniform manner, the contractor may be required to repair them with full width slurry surfacing.

<u>Designer's Note:</u> In certain project situations (freeway ramps, cul-de-sacs, irregular pavement widths/geometries, etc.), specifications may require the use of application equipment with driving controls on both sides of the equipment.

T. Poorly Constructed Transverse Joints

<u>Condition:</u>

- Excessive build-up or uneven transition
- Unsightly appearance
- Uncovered areas
- Overlap

Figure 66 - Unacceptable Transverse Joint (Overworked)

<u>Possible Causes:</u>

- Improper box operation, resulting in an application that is too heavy or too light
- Performing excessive handwork
- Poor workmanship
- Butt joint was not constructed properly

<u>Prevention:</u>

- Operate the spreader box to maintain a consistent application elevation at the transition so that no more than 6.4 mm (0.25 inch) is measured when a 3 meter (10 foot) straight edge is placed perpendicular to the transverse joint and parallel to the wheel path.
- Avoid overworking the material which can lead to segregation.
- Eliminate gaps or uncovered areas at the transverse joint.
- Require that transverse joints be constructed as butt joints since any overlap at a transverse joint will negatively affect ride quality.

<u>Inspector's Note:</u> Following construction, even well-constructed joints may exhibit some level of roughness, but this should diminish rather quickly with traffic. If the transverse joints are not neat, straight and perpendicular to the direction of placement, the contractor may be required to repair the affected area with a full width pass.

Designer's Note: *The total number of transverse joints, other than those required by bridges, structures and repairs should be minimized. If transverse joints are a concern, use of a continuous machine should be specified.*

U. Poorly Constructed Edge Lines

Condition: The slurry surfacing edge lines do not appear uniform or are not properly aligned with the shoulders or curb lines.

Figure 67 - Unacceptable Edge Line

Possible Causes:

- The crew had difficulty following the edge line or curb line.
- The mixture contains an excessive amount of liquid (has unacceptable consistency).

Prevention:

The specification should require compliance with the following measures:

- Operate the spreader box and align the application equipment so that the edge does not vary more than ± 75 mm (3 inches) on a 30 meter (100 foot) straight section or 30 meter (100 foot) arc in a curved section.
- Maintain accurate equipment calibration, adhere to the JMF and maintain the proper mix consistency necessary to produce straight edge lines.

V. Failure to Correct Rutting (Specific to Micro Surfacing Only)

Condition: Even though the rut filling project and materials were properly selected, the final rut filling application did not correct the depressions in the wheel paths.

Possible Causes:

- Underfilled rut
- Improperly crowned rut
- Application of emulsified asphalt at the higher end of the mix design tolerances
- Improperly operated and maintained rut box
- Premature release to traffic
- Premature application of surface course after rut filling

Prevention:

- Monitor rut filling operations with a straightedge to ensure that the ruts are being filled completely.
- For every inch of rut depth, add a 3.2 mm (0.125 inch) to 6.4 mm (0.25 inch) crown to allow for compaction under traffic.
- Apply the mixture at the lower end of the emulsified asphalt mix design tolerance.
- Adjust the box as the rut depth changes and clean as needed.
- Ensure that the application has cured sufficiently to support return to traffic.
- Require a minimum of 24 hours of traffic for compaction before placing the final surface course.

Designer's Note: *For more information on proper site selection on rut filling, refer to Section VI.E.4, Rut Filling.*

W. Damage from Premature Opening to Traffic

Condition: Due to early release to traffic, damage has occurred on the slurry surfacing material such as:

- Loss of aggregate (raveling)
- Flushing in the wheel paths
- Loss of skid-resistance or surface texture

Figure 68 - Flushing Due to Premature Release to Traffic

Possible Cause: Early release to traffic

Prevention: It is ultimately the contractor's responsibility to work with the agency to assess the suitability of the application for release to traffic. Release of traffic does not constitute acceptance of work. The contractor is ultimately responsible for damage that occurs from early release to traffic.

Inspector's Note: *Refer to Section VI.E.1, page 46, Ambient Conditions for Application, for more information. The magnitude of the damage may require the contractor to repair the affected area with a full width pass.*

X. Tire Marks in Freshly Applied Material

Condition: Tire tracks are highly visible in the finished surface.

Figure 69 - Damage from Early Traffic

Possible Cause: Occasionally, a vehicle will drive across the slurry surfacing before it has gained adequate strength, leaving behind distinct tire tracks. The traffic control plan may not have adequate flaggers and devices necessary to prevent vehicle entry into the work zone.

Prevention: Thoroughly review the traffic control plan to ensure no unauthorized vehicles can enter the work zone. Broadcast slurry surfacing aggregate on fresh material near active driveways or intersections to help eliminate any bonding of the slurry surfacing to vehicle tires.

Inspector's Note: The magnitude of the damage on the project shall be assessed by the agency and the contractor to determine which areas will need to be repaired. The high ridges from tire treads may require heating and raking prior to repairing with a full width pass. These repairs will leave transverse joints which will eventually blend into the new slurry surfacing.

Y. Unacceptable Handwork

Condition: Areas where handwork was performed may be segregated, unsightly, have uncovered areas or a non-uniform texture.

Figure 70 - Unacceptable Handwork

Possible Causes:

- Material was setting too quickly for handwork
- Inadequately trained crew
- Overworking of material leading to segregation
- Attempting to handwork too large of an area
- Application conditions (air and pavement temperatures)

Prevention:

- Use additives to increase workability.
- Ensure an adequate work force is trained and available to work quickly and efficiently.
- Avoid overworking the material to eliminate segregation.
- Divide larger sections requiring handwork into small areas and work on one small area before proceeding to another.
- Dampen pavement prior to placing material. Schedule areas requiring handwork in the cooler parts of the day.

Inspector's Note: *Refer to Section VI.E.6, page 55, Handwork, for more information.*

IX. SPECIAL SITUATIONS

These conditions may be experienced at times with all slurry surfacing systems, unless otherwise noted.

A. Multiple Lifts (Specific to Micro Surfacing Only)

Micro surfacing has the added strength and stability to allow placement of multiple lifts at heavier application rates. There is an optimal rate specific to the aggregate gradation and the existing pavement surface. When heavier applications of micro surfacing are applied, the aggregate may become 100% embedded leaving a flushed or smooth surface texture. In these situations, a final surface course will provide a high friction, durable wearing surface.

Designer's Note: *Multiple applications of slurry seals or polymer-modified slurry seals are not recommended.*

B. Cul-de-Sacs

A cul-de-sac has only one inlet/outlet that dead ends in a traffic circle. If the application equipment cannot navigate the full radius of the circle, handwork preceding machine application is recommended over a sufficient area so that the machine will be able to cover any remaining areas. More cure time may be needed in cul-de-sacs because of the higher stresses applied by tight turning vehicles.

Inspector's Note: *If handwork is performed, it should exhibit a uniform application rate and surface texture to sufficiently match that applied by the spreader box.*

Figure 71 - Finished Treatment on Cul-de-sac

C. Excessively Rich, Flushed, or Bleeding Asphalt Surfaces (Specific to Micro Surfacing Only)

Special application techniques are necessary when applying micro surfacing over pavements with excess asphalt on the surface. Because the flushed area lacks surface texture, it is difficult to achieve the desired application rate because the rear strike-off on the spreader box tends to wipe the micro surfacing material from the surface. To correct this, a flexible rear strike-off should be used rather than a rigid strike-off.

Designer's Note: *When correcting flushed pavements, a mixture with a reduced residual asphalt content and higher application rate may be necessary. A double application may be preferred. The first application can be very thin and used much like a scratch course. The second application will then adhere well to the scratch course at the correct application rate. Repairs should be addressed in cooler application conditions.*

D. Expressway Shoulders and Ramps

Traffic is a concern in these areas due to high speeds and extended work zone lengths. On and off ramps/gore areas create a need for special traffic control and crew awareness. Motorists are preoccupied with entering the freeway, and their attention is already divided. All crew members need to be aware of the heightened concern for a safe operation. Equipment operators need to be aware of the high-speed traffic when entering and exiting the work zone with slow moving application equipment.

Due to their odd shapes and sizes, ramps/gore areas need special planning to avoid large areas of overlap. Attention is also needed to assure that the longitudinal joints and edges are straight and uniform.

Designer's Note: *Specifying short passes with tapers and the use of a variable width spreader box can aid in eliminating overlap.*

E. Filling Large Cracks

Due to economics and because conventional crack sealants are not typically designed to seal excessively large cracks, some projects may require the use of a slurry surfacing mixture as a crack filling material. If required, that should be a separate operation from the normal slurry surfacing application. There are two methods for applying the slurry surfacing mixture for this purpose.

- Build a small box as a holding compartment for the slurry surfacing mixture. Using the application equipment, fill the box then manually pull transversely or longitudinally along the road over the crack.
- Park the application equipment over the top of the crack and drop the material onto the crack. The material can then be spread across the crack with a conventional or "V" shaped squeegee.

Designer's Note: When a slurry surfacing mixture is used as a crack filler, the crack will eventually migrate through the mix but at a smaller width than originally existed. Once the new crack is observed it becomes practical and cost effective to fill the crack with an effective crack sealant.

F. Grinding and Milling of Pavement (Specific to Micro Surfacing Only)

Micro surfacing is a very effective method of covering a finely textured, full-lane drum milled section of pavement. The cold milling machine equipped with automatic controls for establishing profile grades and a micro-milling drum with a denser tooth configuration than a conventional drum ensure a smoother riding micro surfacing. The liquid nature of the micro surfacing will allow it to flow into the milled surfaces for tight bonding.

Designer's Note: Micro surfacing can be used as an interlayer over a milled surface. If micro surfacing is the final surface treatment it should be specified as a double application.

G. Partial Width Passes

Occasionally it is not possible to apply a slurry surfacing treatment using all full width passes. To avoid overlap in such cases, partial width passes may be used. The operator directs the diverter to supply a portion of the spreader box, using the augers to assist in placement of the mix where needed. A partial pass should never be the final pass.

Designer's Note: Specifying the use of a variable width spreader box can aid in eliminating overlap.

H. Placing Next to Structures

Mixture being discharged from the pugmill and the action of the augers in the spreader box can splash the slurry surfacing on adjacent buildings or structures. Masking exposed areas with plastic sheeting and duct tape and the addition of a shield mounted on the spreader box can minimize exposure. If the mixture splashes onto a structure, the crew should remove it immediately. Areas that are inaccessible to the spreader box should be placed using handwork.

Inspectors' Note: It's important that the crew be proactive in taking the necessary measures to keep the slurry surfacing mixture off structures as opposed to cleaning up afterwards.

I. Protecting Special Markings and Utility Castings

Although masking special pavement markings was common practice in the past, it is now believed that the ridge created around the stencil creates a ponding problem that promotes pavement deterioration.

Certain castings and structures should be referenced by measurements so they can be found later. The use of temporary marking tabs also assists in locating castings and structures after treatment placement. This eliminates problems with relocating the cover to be removed if the treatment erases the location outline.

Figure 72 - Existing Thermoplastic Markings

Figure 73 - Protecting Existing Thermoplastic Marking Prior to Micro Surfacing
(at customer's request – not recommended as ridges will create ponding of rainwater)

<u>Designer's Note:</u> It is recommended that special markings be removed and replaced as outlined in Section VI.B.2, page 42, Removal of Pavement Markings.

J. Rolling of Slurry Systems

Seldom required for most slurry surfacing systems, rolling is used for some airport projects and parking lots that may not receive the desired traffic compaction or where loose aggregate may cause foreign object damage. If rolling is specified, a rubber-tired roller should be used. This will allow the tires to knead the surface and compact all areas. Use of steel wheel rollers should be avoided as they tend to bridge across the high spots and fail to compact low areas, crush larger aggregates, and scratch and mark the surface.

Compaction is achieved with two passes from a 10 to 12-ton pneumatic tired roller. Rolling should be done as soon as the mixture is set enough to support the roller. Water with a small amount of detergent can be used to wet roller tires to avoid pickup.

K. Thermo Plastic Markings/Plastic Tape Markings

It is important to remove any thermoplastic and plastic tape lane delineation markings before applying a slurry system treatment. The treatments will not adhere properly to the plastic markings and will wear off very quickly. Although the new marking is to be placed over the same location as the existing marking, the original marking should be removed.

Existing conventional painted lines that have been repainted many times and have a thick paint buildup, especially those with embedded glass beads, may also present an adhesion problem. Consider removing or abrading the heavily built up areas.

Pavement markings to be reinstalled in the same alignment as prior to treatment should be referenced with temporary pavement marking tabs. These tabs are typically used for chip seal applications. They should be cut into narrow strips and placed as aids to mark the layout after resurfacing.

L. Grade Flow

Slurry surfacing mixtures may flow by gravity on crowns, super elevated curves, and steep grades. Spreader boxes that are not equipped with an auger distribution system, allow the slurry surfacing mixture to flow by gravity toward the low end of the box. As a result, the slurry surfacing will flow laterally on crowns and super elevated curves.

Partial compensation for flow can be made by an experienced operator who can divert the mixture to the higher part of the spreader box. For an uphill application a more fluid slurry surfacing mixture is recommended. This offsets mixture pressure on the strike-off squeegee which creates a layer thicker than desired. A downhill application should use a stiffer mixture. This will counteract the tendency of the slurry surfacing mixture to escape under the front squeegee.

The best solution to this problem is use a spreader box equipped with augers (spiral or paddle type) to distribute the slurry surfacing mixture. Most augured spreader boxes allow the operator to activate the augers on either the right or left side, separately or in unison. The operator can also control the direction of rotation and the speed of each pair of augers. With proper use of the augers, a uniform mat can be placed regardless of the degree of crown or bank.

X. APPENDICES

A. Glossary of Terms

Breaking - The initial separation of the water from the emulsified asphalt, which can be detected by a marked color change from brown to black, and often by the release of fairly clear to straw-brown water. This characterizes the point when asphalt droplets begin to re-combine. The results in the deposition of the base asphalt on a paved surface and the material can no longer be hand-worked.

Colloid - Any fine suspension of finely divided particles in a continuous medium.

Colloid mill - A type of rotor-stator mixer used in the manufacturing of emulsified asphalt.

Cure - The entire process of breaking and setting of a slurry surfacing mixture. When the residual asphalt has coalesced into a continuous film surrounding the aggregate particles and most of the water has been forced from the mat through chemical reaction and/or evaporation, the application is ready for traffic. It should be noted that a complete cure (total dehydration) can take periods of from two to four weeks.

Edge - The point that the aggregate in a slurry surfacing system treatment ends.

Emulsifier (See Surfactant)

Emulsified Asphalt - A homogeneous combination of asphalt, water and emulsifier (surfactant). In the manufacturing process, these components are introduced into a colloid mill, which shears the asphalt into tiny droplets. The emulsifier molecules keep the asphalt droplets in a stable suspension as well as control the break time of the emulsified asphalt.

Gore – The triangular area located between a highway and an entrance/exit ramp.

Lift - A layer or course of paving material applied to a base or a previous layer.

Micro Surfacing Emulsified Asphalt - Polymer-modified emulsified asphalt with special chemical compositions enabling placement of thick lifts of "slurry surfacing". They are normally cationic.

Particle Charge Test - The particle charge test is made to identify cationic emulsified asphalt. It is performed by immersing a positive electrode (anode) and a negative electrode (cathode) into a sample of emulsified asphalt and connecting them to a controlled direct-current electrical source. At the end of a specified time period, the electrodes are observed to determine which pole has an appreciable layer of asphalt deposited on it. Cationic emulsified asphalt will migrate towards the cathode.

Penetration – An empirical measure of the consistency of an asphaltic material, conveyed as depth in tenths of a millimeter, that a standard needle penetrates into a sample under a specific load, for a defined time and at an established temperature.

Polymer-Modified Emulsified Asphalt - These emulsified asphalts contain modifiers in the form of finely dispersed polymers. These modifiers may be blended into the asphalt prior to the manufacturing of the emulsified asphalt, co-milled with the asphalt during the milling process, or added to the emulsified asphalt after the manufacturing process has been completed. Polymers are added to increase strength, reduce temperature susceptibility, and to improve adhesion and stability.

Pugmill - A mixing chamber containing either a ribbon-type mixer or rotating shafts with paddles. Individual components (aggregate, emulsified asphalt, mineral filler, water and additive) are continuously fed to the front while a homogeneous mixture of all these components is continuously delivered out of the back to the spreader box.

Quick-Set Emulsified Asphalt – Emulsified asphalt for slurry surfacing systems break and set primarily because of electrical charge interactions between the aggregate and the emulsified asphalt. CSS-1h emulsified asphalt can be formulated as a quick-set and are normally designated as CQS-1h. Anionic quick-set emulsified asphalt is normally designated as QS-1h.

Residue from Distillation - The distillation test determines the relative amount of residual binder in the emulsified asphalt and also results in a sample of that residue for further testing.

Ring & Ball Softening Point – The term relates a measure of consistency for asphalts. Samples of asphalt loaded with steel balls are confined in brass rings suspended in a beaker of water one inch above a metal plate. The liquid is heated at the prescribed rate. As the asphalt softens, the balls and asphalt gradually sink toward the plate. At the moment the asphalt touches the plate, the temperature of the water is recorded and this is designated as the Ring & Ball Softening Point.

Set - The point when the emulsified asphalt breaks, the asphalt residue coats the aggregate particles and clear water is released from the system. A slurry surfacing system is considered set when no brown stain is transferred to a white paper towel that is pressed on the surface of the mixture.

Set Control Additives - Defined as small amounts of materials (mineral fillers or chemical) that when added to a slurry surfacing mixture, speed or retard the setting characteristics of that mix.

Setting - A point when all asphalt particles have broken and combined into larger particles. This is observed when the material becomes rain safe and will support foot traffic.

Settlement - This test method addresses the ability of an emulsified asphalt to remain as a uniform dispersion during storage. A prescribed volume of material is allowed to stand in a graduated cylinder for a specified period of time. Samples are taken from the top and bottom parts of the cylinder and weighed into a beaker. The water is evaporated off the samples, the residue percentages determined, and the difference between the upper and lower portions calculated to provide a measure of the settlement over that time period.

Sieve Test - This test method covers the degree to which an emulsified asphalt may contain particles of asphalt or other discreet solids retained on a 850-µm mesh sieve. A representative sample of emulsified asphalt is poured through a 850-µm mesh (No. 20) sieve. For anionic emulsified asphalts, the sieve and retained asphalt are then rinsed with a mild sodium oleate solution and finally with distilled water. For cationic emulsified asphalts, distilled water is used instead of sodium oleate solution. After rinsing, the sieve and asphalt are dried in an oven and the amount of retained asphalt determined.

Slow-Set Emulsified Asphalts – These emulsified asphalts are stable when diluted and able to mix with cement as an indication of their suitability for use with aggregates having high surface area. When this type of emulsified asphalt is used for slurry surfacing, the break and set is almost entirely due to the evaporation of the water. Typical designations are SS-1h (anionic) and CSS-1h (cationic).

Stator - The fixed or stationary plate of a colloid mill. Emulsified asphalts are formed when two immiscible liquids are introduced into a cavity with a small clearance between the stator and a high speed rotor creating high shear forces.

Surfactant - (Surface-active agent) – A substance which tends to reduce the surface tension of a liquid in which it is dissolved. In emulsified asphalts, the surfactant (emulsifier) acts at the interface of the asphalt and water phase keep the asphalt droplets in a stable suspension.

Uniform Cross-Section - The area where the pavement width is greater than the width of the slurry system treatment placed and there are no drop-offs greater than 12.5 mm (0.5 inch).

Viscosity - The Saybolt Furol viscosity test as described for emulsified asphalts is used both for the anionic and cationic emulsified asphalts to measure and specify consistency properties. As a matter of testing convenience and also to achieve suitable testing accuracy, two testing temperatures [25º C (77ºF) and 50ºC (122ºF)] are used, depending on the viscosity characteristics of the specific type and grade of the emulsified asphalts.

B. Test Methods

The following standards and test methods are applicable to the construction of slurry systems and may be used to ensure compliance of specifications.

AASHTO - American Association of State Highway and Transportation Officials
ASTM - American Society for Testing and Materials
ISSA - International Slurry Surfacing Association

AGGREGATE AND MINERAL FILLER

AASHTO Test	ASTM Test	Test
T2	D75	Sampling Mineral Aggregates
T27	C136	Sieve Analysis of Aggregates
T11	C117	Materials Finer than 200 Sieve Mineral Aggregate
T176	D2419	Sand Equivalent Value
T84	C128	Specific Gravity and Absorption of Fine Aggregate
T19	C29	Unit Weight of Aggregate
T96	C131	Resistance to Abrasion of Small Side Coarse Aggregate by use of the Los Angeles Test Method
T37	D546	Sieve Analysis of Mineral Filler
T104	C88	Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate
T90		Determining the plastic limit and the plastic index of soils

EMULSIFIED ASPHALT

AASHTO Test	ASTM Test	Test
T40	D140	Sampling Material
T59	D244	Test Methods and Practices for Emulsified Asphalts
M140	D977	Specification for Emulsified Asphalt
M208	D2397	Specification for Cationic Emulsified Asphalt

SLURRY SURFACING SYSTEM TEST METHODS

ISSA Test	ASTM Test	Test
T100		Test Method for Wet Tract Abrasion of Slurry Seals
T101		Guide for Sampling Slurry Mix for Extraction Test
T106		Measurement of Slurry Seal Consistency
T109		Test Method for Measurement of Excess Asphalt by Use of a Loaded Wheel Tester
T112		Method to estimate Slurry Seal Spread Rates and to Measure Pavement Macro-texture
T113		Trial Mix Procedure for Slurry Mix Design
T114		Wet Stripping Test for Cured Slurry Seal Mixes
T139		Modified Cohesion Test
T144		Compatibility by Shulze-Breuer and Ruck Procedures
T147-A		Test Method for Measurement of Stability and Resistance to Compaction, Vertical and Lateral Displacement of Multilayered Fine Aggregate Cold Mixes
	D3910	Design, Testing and Construction of Slurry Seal
	D6372	Design, Testing and Construction of Micro Surfacing

C. Useful Construction Conversions

Area or Square Measure	Volume or Cubic Measure
1 square inch (in^2) = 6.452 cm^2 144 in^2 = 1 ft^2 = 0.0929 m^2 9 ft^2 = 1 yd^2 = 0.8361 m^2 1 m^2 = 1.195 yd^2 = 10.76 ft^2	1 in^3 = 16.39 cubic centimeter (cm^3) 231 in^3 = 1 U.S. gal = 3.7853 liters 1728 in^3 = 1 ft^3 = 0.0283 cubic meter (m^3) 27 ft^3 = 1 cubic yard (yd^3) = 0.0283 m^3 1 m^3 = 1.308 yd^3 = 35.32 ft^3
Linear Measure 1 in. = 1/12 ft = 2.540 cm 12 in. = 1 ft = 30.48 cm = 0.3048 m 3 ft = 1 yd = 0.9144m 1 m = 39.37 in. = 3.281 ft = 1.094 yd 1 mi = 5,280 ft = 1,760 yd = 1.6093 km 1 km = 0.6214 mi	**Liquid Measure** 2 pints (pt) = 1 quart (qt) = 0.9463 liters 4 qts = 1 gal = 3.7853 liters 1 U.S. gal =231 in^3 = 0. 1337 ft^3 1 cu ft = 7.4805 U.S gal = 0.02832 cu m 1 cu ft = 28.32 liters 1 liter = 1.057 qt = 0.2642 U.S gal 1 imperial gal = 1.201 U.S. gal = 277.4 in^3 1 imperial gal = 4.546 liters
Avoirdupois Weight 16 ounces (oz) = 1 lb = 453.6 gm = 1 lb = 0. 4536 kg 1 kg = 1000 g = 2.204 lb 2,000 lbs = 1 short ton = 907.2 kg 2,240 lbs = 1 long ton = 1,016 kg 2,205 lbs = 1 metric ton = 1,000 kg	**Thermometric Equivalents** **Fahrenheit to Celsius** $T_c = (5/9)\cdot(T_f - 32)$ **Celsius to Fahrenheit** $T_f=(9/5)\cdot T_c+32$ (T_c =Celsius, T_f = Fahrenheit)

Quick Equivalents

Water 1 gallon = 8.33 lbs 1 gallon = 231 cubic inches (in^3) = 0.1337 cubic foot (ft^3) 1 cubic foot (ft^3) = 7.5 gallons = 1728 in^3 = 62.5 lbs
Emulsified Asphalt 1 gallon = 8.33 lbs 1 ton = 240 gallons
Aggregate 1 cubic foot (ft^3) ≈ 88 to 112 lbs (weight varies with aggregate type and moisture content)

Helpful Formulas

Circumference of a Circle	Diameter of a Circle
$C = \pi \cdot d$ (π = 3.1416, d = diameter)	$d = C/\pi$ (C = circumference, π = 3.1416)
Area of a Circle $A=\pi\cdot d^2/4$ (π = 3.1416, $d^2 = d \cdot d$)	**Area of a Triangle** A = ½ b h (b = base, h = height)

Conversion Factors

Measurement	Multiplied by	Equals
inches (in)	2.54	centimeters (cm)
feet (ft)	30.48	cm
yards (yd)	0.9144	meters (m)
pounds (lb)	0.4536	kilograms (kg)
short tons	0.9070	metric tons
gallons (gal)	3.7853	liters
ft^2	0.0929	m^2
ft^3	0.0283	m^3
yd^3	0.7646	m^3
lb/ ft^2	4.882	kg/ m^2
lb/ yd^2	0.5424	kg/ m^2
gal/ yd^2	4.527	liters/ m^2
miles (mi)	1.6093	kilometers (km)
mi/hr	1.6093	km/hr

Quick Temperature Conversions

Celsius	Fahrenheit	Celsius	Fahrenheit
0º	32º	40º	104º
5º	41º	45º	113º
10º	50º	50º	122º
15º	59º	60º	140º
20º	68º	70º	158º
25º	77º	80º	176º
30º	86º	90º	194º
35º	95º	100º	212º

D. Inspector's Equipment

Suggested Basic Equipment
• Calculator • Measuring Wheel • Surface Temperature Measuring Device • Forms, notebooks and memo pads • Camera • Shovel • Containers for sampling materials

E. Construction Records

Suggested File Organization of Construction Records
• Daily Log Book and Inspector's Diary • Progress Reports • Correspondence • Payment Invoices • Payroll Records • Change Order • Sampling and Test Reports • Project Memoranda • Punch Lists

Suggested Records - One of the inspector's most important responsibilities is to keep accurate and complete project records. Comprehensive records are necessary to ascertain contract compliance, verify contractor payments, and to provide a complete project history which can be important for future reference. The level of detail required should be such that people unfamiliar with the project can understand what happened from the records alone.

Three types of records should be kept by the inspector for the project:

1. A daily log book,
2. Sampling and testing reports, and
3. Progress Reports.

Daily Log Book (Inspector's Diary): This should be a completed on a daily basis and contain everything that happened on the project. The log book should include the quality of work being inspected, work progress, important conversations, verbal orders, unusual incidents, equipment breakdowns, number of men and equipment on the project, and any other items that pertains to the project. In addition, the quantities of the treatment placed each day, should be recorded by either the square yards or the quantities of aggregate and emulsified asphalt consumed daily, depending upon the project pay items and pay units. It is suggested that quantities are agreed upon by both parties at the completion of each working day. The log book entry should bear the signature and the official title of the inspector.

Sampling and Testing Reports: These reports should include all samples of aggregate, emulsified asphalt, and mixture, with the results of the field test or laboratory test.

Progress Reports: Depending upon the contract, progress reports are sometimes used estimate in calculating payments to the contractor for partial completion. It is common practice to withhold a portion of the contract amount, customarily ten percent, until the entire project is completed and accepted.

Two Examples of "Daily Report – Quantities Used" are given on the following pages.

DAILY REPORT - QUANTITIES USED

LATEX MODIFIED EMULSIFIED ASPHALT TREATMENT TYPE B

ANYTOWN, USA

ROUTE/ROAD	DATE	COUNT	TONS OF EMULSIFIED ASPHALT	TONS OF STONE	BAGS OF MIN FILLER	TONS OF MIN FILLER	BAGS FIBER	TONS FIBER	TOTAL TONS

MICRO SURFACING APPLICATION RATE

ROUTE/ROAD	LENGTH	WIDTH	SQUARE YARDS	TOTAL TONS	TOTAL LBS USED	APPLICATION RATE
			-	-	-	-
			-	-	-	-
			-	-	-	-
			-	-	-	-
			-	-	-	-
			-	-	-	-
			-	-	-	-
			-	-	-	-
		TOTAL	-	-	-	-

TACK COAT APPLICATION RATE

ROUTE/ROAD	GALLONS OF TACK USED	SQUARE YARDS		APPLICATION RATE (Gal/Yd)
				-
				-
		-		-
		-		-
		-		-
		-		-
		-		-
		-		-
		-		-
		-		-
TOTAL	-	-		

DAILY REPORT - QUANTITIES USED

Job Name

Project Information		Completed To Date	% Complete
Square Yards			
Total Rock Tons			
Tot Em Asph Gals			
Total Cement bags			

Calibration Factors	
Rock/count	
Em Asph/count	
Mineral Filler/c	

Job Mix Formula	
Rock	
Emuls Asphal	
Mineral Filler	

From Mix design

Daily Worksheet

						Contract			Contract				Contract			Weather	
Today's Date	Today's SqYds	% of contract SqYds Completed	Total Rock Counts	Lbs of Rock Applied	Lbs of Rock Per Sqy	% of Rock Used	Total Emul Asp Counts	TotEmAsp Gallons	% of Em Asph Gallons used	% Em Asph In Mix	nding Miner Filler Count	lbs Minera Filler used	Bags of Minera Filler Used	% of Mineral iller In Mi	High	Low	Avg.Humidity
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-																
	-			-		Avg		-									

F. Field Calibration Procedure Worksheets

Emulsified Asphalt Calibration Worksheet

Minimum of 50 counts of the rock/aggregate belt counter per sample

Unit Number:________________ Date:________________

Emulsified Asphalt	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count (= Net Wt/Counts)
Sample 1					
Sample 2					
Sample 3					

Input data in blue shaded cells. Calculate data in white cells.

Average lbs / count of Emulsified Asphalt ________

Mineral Filler Calibration Worksheet

Minimum of 10 counts of the fines feeder counter per sample

Unit Number:________________ Date:________________

Emulsified Asphalt	Full Weight (Lbs)	Empty Weight (Lbs)	Net Weight (Lbs) (= Full-Empty)	Number of Counts	Lbs /Count (= Net Wt/Counts)
Sample 1					
Sample 2					
Sample 3					

Input data in blue shaded cells. Calculate data in white cells.

Average lbs / count of Mineral Filler ________

Aggregate Calibration Worksheet

Minimum of 50 counts of the rock/aggregate belt counter per sample

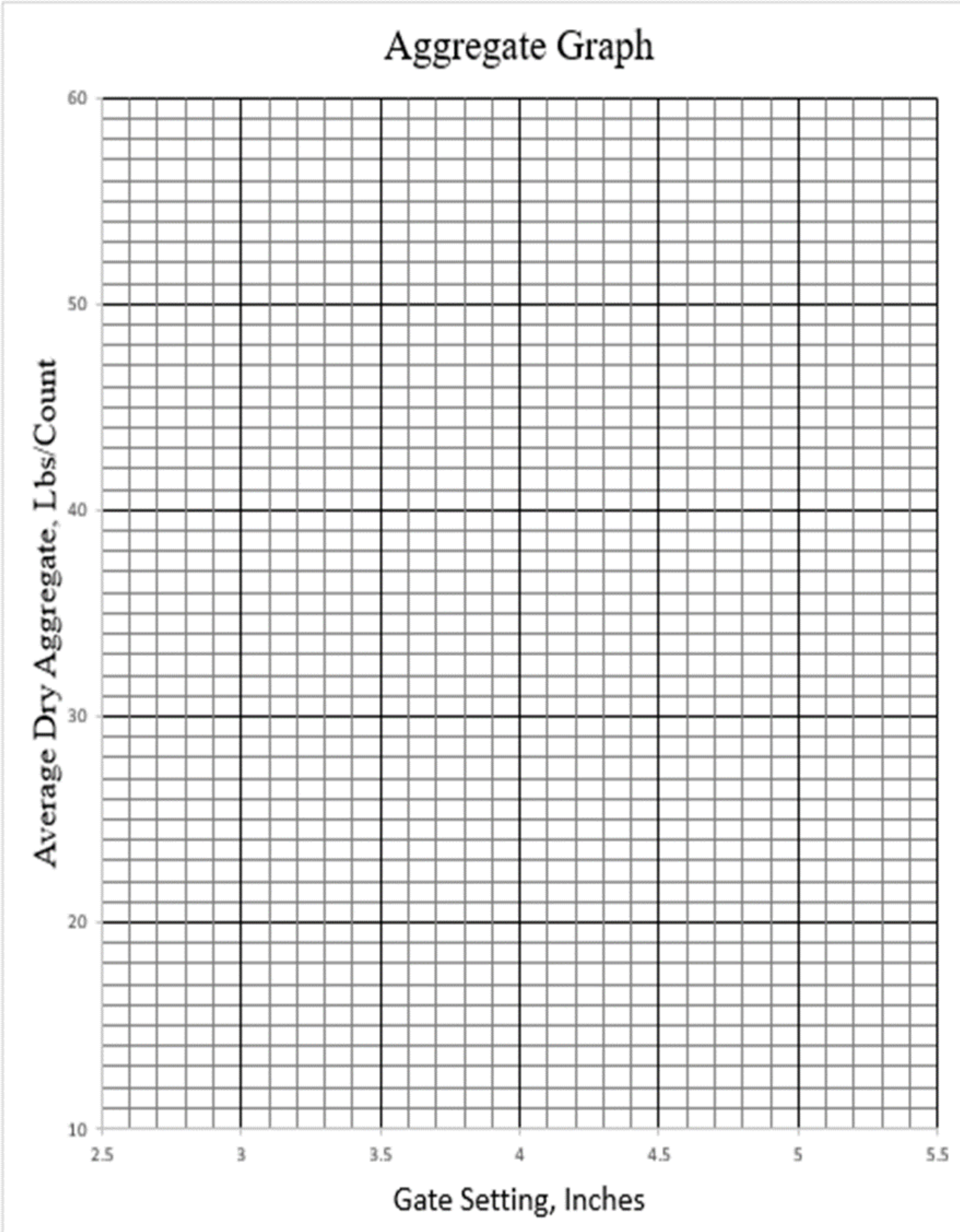
Unit Number:________________ Date:________________

Gate Setting (inches)	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count Wet Aggregate (=Net Wt/Counts)
Sample 1					
Sample 2					
Sample 3					
Avg Wet Agg lbs/count		÷ Moisture Factor		= Avg Dry Agg lbs/count	

Gate Setting (inches)	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count Wet Aggregate (=Net Wt/Counts)
Sample 1					
Sample 2					
Sample 3					
Avg Wet Agg lbs/count		÷ Moisture Factor		= Avg Dry Agg lbs/count	

Gate Setting (inches)	Weight A (Lbs)	Weight B (Lbs)	Net Weight (Lbs) (=A-B)	Number of Counts	Lbs / Count Wet Aggregate (=Net Wt/Counts)
Sample 1					
Sample 2					
Sample 3					
Avg Wet Agg lbs/count		÷ Moisture Factor		= Avg Dry Agg lbs/count	

Input data in blue shaded cells. Calculate data in white cells.


Aggregate Graph
Average Dry Aggregate, Lbs/Count
60
50
40
30
20
10
2.5
3
3.5
4
4.5
5
5.5
Gate Setting, Inches

Calibration Summary Worksheet

Unit Number: ______________________ Date: ______________

Determination of Gate Setting

Choose the calculation procedure (below) based on the information provided on the mix design.

A. GATE SETTING CALCULATION USING PERCENT RESIDUAL BINDER CONTENT IN THE MIX (PREFERRED)

1. Average lbs/count of emulsified asphalt from Emulsified Asphalt Calibration worksheet
2. Percent residual binder content of the emulsified asphalt (provided on the supplier CoA with the load)
3. Percent residual binder content of the mixture (from the JMF on the mix design)

	Average lbs/count emulsified asphalt		Residual binder content of the emulsified asphalt (in decimal form)		Target JMF residual binder content of the mixture (in decimal form)		Dry aggregate lbs/count required to match target JMF residual of the mix
4.		X		÷		=	

5. Gate setting required to provide dry aggregate lbs/count calculated in Step 4 = ______ inches

B. GATE SETTING CALCULATION USING PERCENT EMULSION CONTENT IN THE MIX

1. Average lbs/count of emulsified asphalt from Emulsified Asphalt Calibration worksheet
2. Percent emulsified asphalt content (from the JMF on the mix designn)

	Average lbs/count emulsified asphalt		Percent emulsified asphalt content in the mixture (in decimal form)		Dry aggregate lbs/count required to match target JMF emulsion content of the mix
3.		÷		=	

4. Gate setting required to provide lbs aggregate/count calculated in Step 2 = ______ inches

Input data in colored/shaded cells. Calculate data in white cells.

Mineral Filler Summary Worksheet

Unit Number: ______________ ______________

Determination of Fines Feeder Speed Control Setting at JMF

1. Average dry aggregate lbs/count from the Calibration Summary worksheet (Method A, Step 4 or Method B, Step 3)
2. Aggregate counts/minute at desired production rate

	Dry aggregate lbs/count		Aggregate counts/minute		Dry aggregate lbs/minute
3.		X		=	

4. Percent mineral filler (target from the JMF on the mix design)

	Dry aggregate lbs/minute		Target JMF mineral filler dosage (in decimal form)		Mineral filler lbs/minute required to match JMF from mix design
5.		X		=	

6. Average mineral filler lbs/count from the Mineral Filler Calibration worksheet

	Mineral filler lbs/minute required to match JMF from mix design		Mineral filler lbs/count		Mineral filler counts/minute
7.		÷		=	

Input data in colored cells. Calculate data in white cells.

G. Example of a Slurry Seal Mix Design

Company Letterhead

Slurry Seal Mix Design
Customer Name
Month Date, Year

This Job Mix Formula (JMF) applies to the materials and specification listed below.

Materials

Aggregate:	Aggregate Manufacturer-Quarry Name-Type II (Received Month Date, Year)
Emulsion Source:	Customer Name
Specification:	XDOT Slurry Seal Specification

A series of tests was performed in the lab to optimize the JMF. The cement and aluminum sulfate dosages were varied to establish their effects on mix time. One-hour Wet Track Abrasion and Excess Asphalt by Loaded Wheel Sand Adhesion tests were performed at the JMF cement and aluminum sulfate dosages to establish a working range for the residual solids content of the mix. Cohesion and other mixture tests were verified on the JMF.

JMF (percent based on dry weight of aggregate)

Component	Minimum	JMF	Maximum
Type I/II Portland Cement	0.0	0.5	1.0
Aluminum Sulfate (37% Solution)	0.0	0.5	1.0
Total Water		As needed for consistency	
Emulsion (based on 62.5%)	13.0	14.0	15.0
Residual solids content	8.1	8.8	9.4
Aggregate		100	

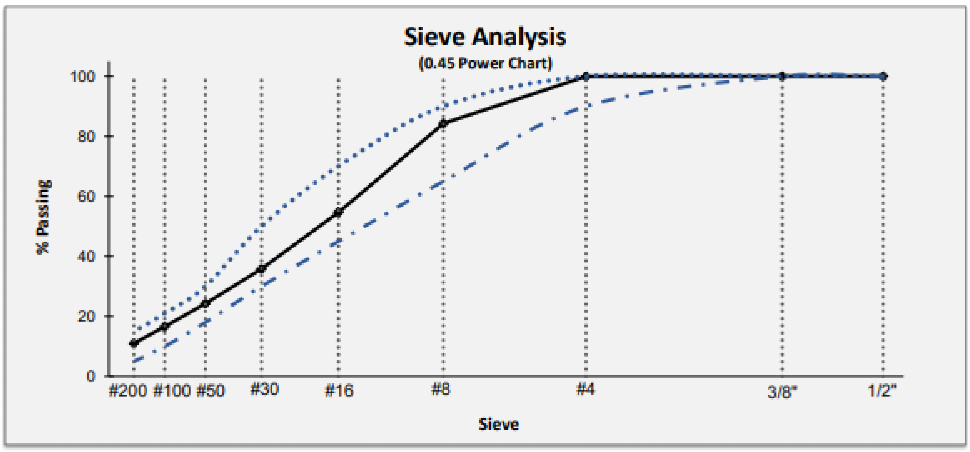
Company Letterhead

Aggregate Testing

Sieve Analysis

Sieve #	Sieve Size (in)	Weight (g)	% Retained	% Passing	Specification
3/8"	0.3750	0.0	0	100	100
4	0.1870	0.4	0	100	90-100
8	0.0937	87.1	16	84	65-90
16	0.0469	165.1	30	55	45-70
30	0.0234	105.2	19	36	30-50
50	0.0117	64.3	12	24	18-30
100	0.0059	42.7	8	17	10-21
200	0.0029	32.6	6	11	5-15
Pan	-	60.2	11	-	-
Totals			100		

Samples were washed with plain water according to ASTM C117 (and AASHTO T11) and sieved according to ASTM C136 (and AASHTO T27).



Sand Equivalent (AASHTO T176)

Result	Specification
55	45 minimum

Company Letterhead

Mixture Testing

Wet Track Abrasion, 1-Hour Soak (ISSA TB 100)

% Emulsion	% Total Water	% Cement	% Alum	Loss (g/m^2)
12.0	8.4	0.5	0.5	770
12.0	8.4	0.5	0.5	673
				722 Average
14.0	7.4	0.5	0.5	714
14.0	7.4	0.5	0.5	795
				754 Average
16.0	6.4	0.5	0.5	515
16.0	6.4	0.5	0.5	518
				517 Average

Excess Asphalt by LWT Sand Adhesion (ISSA TB 109)

% Emulsion	% Total Water	% Cement	% Alum	Adhesion (g/m^2)
14.0	7.4	0.5	0.5	405
16.0	6.4	0.5	0.5	465

Mixture Characteristics, JMF

Test	Details	Method	Spec. Min.	Spec. Max.	Result
Mix Time	77°F	ISSA TB 113	180 sec	-	180
Cohesion	30 minute	ISSA TB 139	12 kg-cm		14
	60 minute	ISSA TB 139	20 kg-cm	-	Spin~23
Wet Stripping		ISSA TB 114	Pass (90%)	-	Pass (100)
Wet Track	1-Hour Soak	ISSA TB 100	-	807 g/m^2	754
Loaded Wheel	Sand Adhesion	ISSA TB 109	-	538 g/m^2	405
Consistency		ISSA TB 106	2.0	3.0	2.3

Please be aware that these results were achieved under laboratory conditions. Raw material samples utilized in this evaluation may or may not be representative of the materials used in the field. Variations in those materials, production equipment, and environmental conditions at the time of application may require adjustments to maintain optimum product performance.

John Smith
Chief Chemist
Phone: (123) 456-7890
john.smith@designlab.com

H. Example of a Micro Surfacing Mix Design

Company Letterhead

Micro Surfacing Mix Design
Customer Name
Month Date, Year

This Job Mix Formula (JMF) applies to the materials and specification listed below.

Materials

Aggregate:	Aggregate Manufacturer-Quarry Name-Type II (Received Month Date, Year)
Emulsion Source:	Customer Name
Specification:	XDOT Micro Surfacing Specification

A series of tests was performed in the lab to optimize the JMF. The cement dosage was varied to establish its effect on mix time. Six-day Wet Track Abrasion and Loaded Wheel Displacement tests were performed at the JMF cement dosage to establish a working range for the residual solids content of the mix. Cohesion and other mixture tests were verified on the JMF.

JMF (percent based on dry weight of aggregate)

Component	Minimum	JMF	Maximum
Type I/II Portland Cement	0.5	1.0	1.5
Total Water		As needed for consistency	
Emulsion (based on 64.5%)	11.0	11.9	13.0
Residual solids content	7.1	7.7	8.4
Aggregate		100	

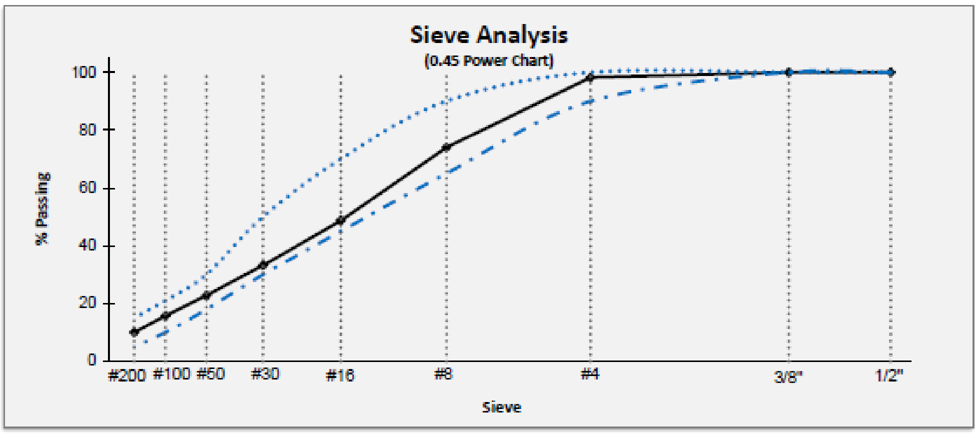
Company Letterhead

Aggregate Testing

Sieve Analysis

Sieve #	Sieve Size (in)	Weight (g)	% Retained	% Passing	Specification
1/2"	0.5000	0.0	0	100	-
3/8"	0.3750	0.0	0	100	100
4	0.1870	9.6	2	98	90-100
8	0.0937	130.4	24	74	65-90
16	0.0469	136.1	25	49	45-70
30	0.0234	83.1	15	33	30-50
50	0.0117	55.8	10	23	18-30
100	0.0059	38.1	7	16	10-21
200	0.0029	30.3	6	10	5-15
Pan	-	54.0	10	-	-
Totals			100		

Samples were washed with plain water according to ASTM C117 (and AASHTO T11) and sieved according to ASTM C136 (and AASHTO T27).



Sand Equivalent (AASHTO T176)

Result	Specification
72	65 minimum

Company Letterhead

Mixture Testing

Wet Track Abrasion, 6-Day Soak (ISSA TB 100)

% Emulsion	% Total Water	% Portland Cement	Loss (g/ft^2)
11.0	7.9	1.0	66
11.0	7.9	1.0	54
			60 Average
11.9	7.1	1.0	41
11.9	7.1	1.0	49
			45 Average
13.0	6.4	1.0	22
13.0	6.4	1.0	28
			25 Average

Wet Track Abrasion, 1-Hour Soak (ISSA TB 100)

% Emulsion	% Total Water	% Portland Cement	Loss (g/ft^2)
11.9	7.9	1.0	30
13.0	7.1	1.0	15

Loaded Wheel Test, Stability and Resistance to Compaction (ISSA TB 147)

% Emulsion	% Total Water	% Portland Cement	Lateral Displacement (%)
11.9	7.1	1.0	1
13.0	6.4	1.0	2

Excess Asphalt by LWT Sand Adhesion (ISSA TB 109)

% Emulsion	% Total Water	% Portland Cement	Adhesion (g/ft^2)
11.9	7.1	1.0	32
13.0	6.4	1.0	39

Company Letterhead

Schulze-Breuer and Ruck Compatibility (ISSA TB 144)

Criteria	Sample A	Sample B	Sample C	Sample D	Points
Absorption (g)	0.9	0.8	0.8	1.0	-
Abrasion Loss (g)	0.6	0.6	0.6	0.7	4
Integrity (%)	92	96	89	95	4
Adhesion (%)	100	100	100	100	4
				POINT TOTAL	12

Mixture Characteristics, JMF

Test	Details	Method	Spec. Min.	Spec. Max.	Result
Mix Time	77°F	ISSA TB 113	120 sec	-	120
Cohesion	30 minute	ISSA TB 139	12 kg-cm	-	Spin~23
	60 minute	ISSA TB 139	20 kg-cm	-	Solid Spin~26
Wet Stripping		ISSA TB 114	Pass (90%)	-	100
Wet Track	1-Hour Soak	ISSA TB 100	-	50 g/ft^2	30
	6-Day Soak	ISSA TB 100	-	75 g/ft^2	45
Loaded Wheel	Lateral Displacement	ISSA TB 147	-	5%	1
	Specific Gravity	ISSA TB 147	-	2.10	1.90
Excess Asphalt	Sand Adhesion	ISSA TB 109	-	50 g/ft^2	32
Classification Compatibility[1]	SBR	ISSA TB 144	11 Points	-	12

[1]The dried aggregate was screened to 100% passing the No. 10 sieve.

Please be aware that these results were achieved under laboratory conditions . Raw material samples utilized in this evaluation may or may not be representative of the materials used in the field. Variations in those materials, production equipment, and environmental conditions at the time of application may require adjustments to maintain optimum product performance.

John Smith
Chief Chemist
Phone: (123) 456-7890
john.smith@designlab.com

I. ISSA A-105 Recommended Performance Guideline for Emulsified Asphalt Slurry Seal

The most current version of the ISSA A-105 Guidelines can be downloaded at no charge from the ISSA website at https://www.slurry.org/page/guidelines.

J. ISSA A-115 Recommended Performance Guideline for Polymer-Modified Emulsified Asphalt Slurry

The most current version of the ISSA A-115 Guidelines can be downloaded at no charge from the ISSA website at https://www.slurry.org/page/guidelines.

K. ISSA A-143 Recommended Performance Guideline for Micro Surfacing

The most current version of the ISSA A-143 Guidelines can be downloaded at no charge from the ISSA website at https://www.slurry.org/page/guidelines.