Training Development for Pavement Preservation

Final Report
May 2013

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Institute for Transportation

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16. Abstract

This research project strives to help the Iowa Department of Transportation (DOT) fully achieve the full benefits of pavement preservation through training on proper selection, design, and application of pavement preservation treatments. In some cases, there is a lack of training when conducting one of these steps and the objective of applying pavement preservation techniques is compromised.

Extensive amounts of literature on pavement preservation exist, but a structured approach on how to train staff in selecting, designing, and applying pavement preservation techniques is lacking. The objective of this project was to develop a training-oriented learning management system to address pavement preservation treatments (chip seals, fog seals, slurry systems, and crack seals and fills) as they are dealt with during the phases of selection, design, and construction.

Early in the project, it was critical to identify the staff divisions to be trained and the treatments to be included. Through several meetings with the Iowa DOT, three staff divisions were identified: maintenance staff (in charge of selection), design staff, and construction staff. In addition, the treatments listed above were identified as the focus of the study due to their common use.

Through needs analysis questionnaires and meetings, the knowledge gap and training needs of the agency were identified. The training modules developed target the gap from the results of the needs analysis. The concepting (selection) training focuses on providing the tools necessary to help make proper treatment selection. The design training focuses on providing the information necessary on the treatment materials (mostly binders and aggregates) and how to make proper material selection. Finally, the construction training focuses on providing equipment calibration procedures, inspection responsibilities, and images of poor and best practices.

The research showed that it is important to train each division staff (maintenance, design, and construction) separately, as each staff division has its own needs and interests. It was also preferred that each treatment was covered on an individual basis. As a result of the research, it is recommended to evaluate the performance of pavement preservation treatments pre- and post-training continuously to compare results and verify the effectiveness of the learning management system.

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TRAINING DEVELOPMENT FOR PAVEMENT PRESERVATION

Final Report
May 2013

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EXECUTIVE SUMMARY

With an increasing effort to keep roadways at high performance levels (good condition), transportation and highway agencies are focusing increasingly on pavement preservation. Even though there are many pavement preservation treatments available, there are few structured training programs to aid in the selection, design, and application of them.

When pavement preservation projects fail to provide the expected benefits, some will argue that this underachievement can be attributed to a lack of experience, knowledge, or training of those involved. This project aimed to address this issue by developing a learning management system (LMS) focused on providing the tools and knowledge necessary to prepare road or highway agency staff to participate effectively in pavement preservation activities of selection, design, and construction.

When developing this LMS, it was important to consider the intended audience. In this case, the audience was expected to be adults with some experience, which may not necessarily include pavement preservation. In addition, it was important to consider the availability and schedule of the audience before making decisions about how to approach the training program.

This training-oriented LMS for pavement preservation has been developed for the Iowa Department of Transportation (DOT). The training program will serve the purpose of preparing practitioners for the responsibilities of selecting, designing, and constructing/applying pavement preservation techniques, specifically seal coats/chip seals, fog seals, slurry systems, and crack sealing/filling. The training program consists of a series of training modules structured to address each treatment at each of the three project phases individually, plus the addition of an introductory presentation to each treatment.

This project also developed a method for creating a training program that addresses the needs of a certain group. The training modules developed target specific needs of the future trainees. The steps taken in this project are not effective solely for pavement preservation training. The same steps can be put into practice in other fields where conditions are similar.

The main advantage of the method presented is that it allows for iterations of the training development process until the developers converge on a product. This is superior to a trial-and-error approach, which could require more drastic changes late in the development process.

INTRODUCTION

Problem Statement

Existing pavement preservation literature addresses the benefits of using pavement preservation and provides descriptions of the design and application processes and materials, among many other subjects.

Unfortunately, information about training for pavement preservation is scarce and no research has been conducted to find appropriate methods to develop pavement preservation training. Many agencies and institutes conduct occasional training on pavement preservation, but there are limited examples and many are relatively unstructured.

The aim of this research project was to develop a structured learning management system (LMS) using the Iowa Department of Transportation (DOT) as a case study. Highways and roadway agency staff from various divisions will benefit from the findings of this research. The staff divisions involved are maintenance staff (who select the road and treatment to be applied), design staff, and construction staff.

The findings from this project will help developers devise training programs for professionals on the proper selection, design, and application of pavement preservation treatments for the purpose of keeping roads at high levels of performance. Although pavement preservation includes many different treatments, the research project focused on chip sealing or seal coating, fog sealing, slurry systems, and crack sealing and filling.

Research Objective

The research objective was to develop a LMS that addresses training for pavement preservation treatments as they are dealt with during the phases of selection, design, and construction. Each staff division (maintenance, design, and construction) needed their own training on pavement preservation treatments in a way that fit their needs appropriately.

In addition, the training method used for each staff division varied. For example, the construction division benefited most from an on-demand short video that they can watch right before application, while maintenance benefited more from a longer face-to-face session where they can share opinions and experiences.

The LMS that was developed also allows for structured access to the desired training. For example, an agency employee interested in the design of chip seals or seal coats can have direct access to a training module prepared specifically for the design of chip seals.

Methodology Summary

The methodology used in this research followed a combination of action research methods along with a job training structure. The job training structure allows for the development of a training program in a quick and effective manner taking into account the current knowledge and experience level of the trainees (Nolan 1996).

The action research method allows for the continuous development of a process and improvement of results (Azhar 2010). Figure 1 represents the combination of both methods as it applies to this research project.

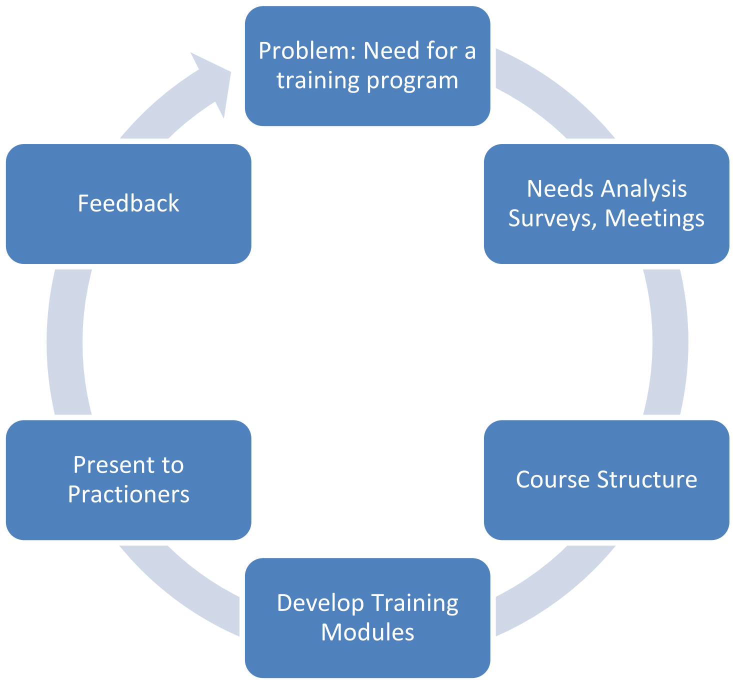

Figure 1. Research methodology

The first cycle started by identifying/diagnosing the problem. Then, through means of questionnaires and meetings, data were gathered regarding the level of knowledge that prospective trainees have on pavement preservation in each of its phases.

Data were analyzed to determine areas that needed to be strengthened. With the data analyzed, it was important to create a course structure that would satisfy the needs, responsibilities, and schedules of the trainees (Table 1).

With a structured course, several training modules were developed for each treatment in each of its phases. To validate the modules, the developed presentations were presented to practitioners. Practitioners provided the research team with feedback regarding areas of improvement and possible changes to the presentations, which in turn ended the first cycle.

Table 1. Training course structure

Presentation Category	Treatments				
	Seal Coating		Fog Sealing	Slurry Systems	Crack Sealing/Filling
Treatment Intro	x	x	x	x	x
Concepting (selection)	x				
Design	x	x	x	x	x
Construction	x		x	x	x

x marks a prepared presentation

The second cycle consisted of improving the presentations developed previously given the data that were gathered and with the feedback received. The course could be restructured, if necessary, in case the feedback led to this conclusion. However, this was not the case on this project.

With the feedback received, most of the updates and changes came in the training module development phase. After the modules were adjusted according to the feedback received, they were presented for final implementation and further feedback.

The development of the needs analysis questionnaires was critical for determining how the training presentations would take shape. When developing the needs analysis questionnaires, the research team analyzed the literature on pavement preservation and each treatment and structured the statements and questions around the most relevant information.

Subjects repeated consistently in various sources were considered most relevant and, therefore, were included in the questionnaires. In addition, professionals with knowledge in the field provided their input on the questionnaires before they were actually distributed.

The following chapters provide details about the content included in each of the training modules, except for the introductory modules. Although not presented in this report, the questionnaire results were analyzed and the presentation content was adjusted to address areas in need of more attention properly.

The concepting and design training modules were prepared to be used in face-to-face training where attendees can share their experiences, although the modules can also be used as online references. The construction training modules were prepared to be conducted online (and on demand) in a short time slot, allowing trainees to prepare for construction only days or hours prior to application.

CONCEPTING (SELECTION) TRAINING MODULE

Overview

Concepting refers the process of road and treatment selection. The goal of the concepting training is to prepare the maintenance staff to select the right treatment for the right road at the right time (also known as the three Rs of pavement preservation).

Subjects incorporated in the concepting training module include road behavior, 3Rs of pavement preservation, road selection process, road conditions and distresses, and treatment overview. Twenty-one questionnaires were collected and analyzed.

Training Module Content

Road Deterioration

This subject is critical in understanding the main point of pavement preservation and it was necessary to show a typical road deterioration curve and point out its most critical elements. Figure 2 was presented in the training module.

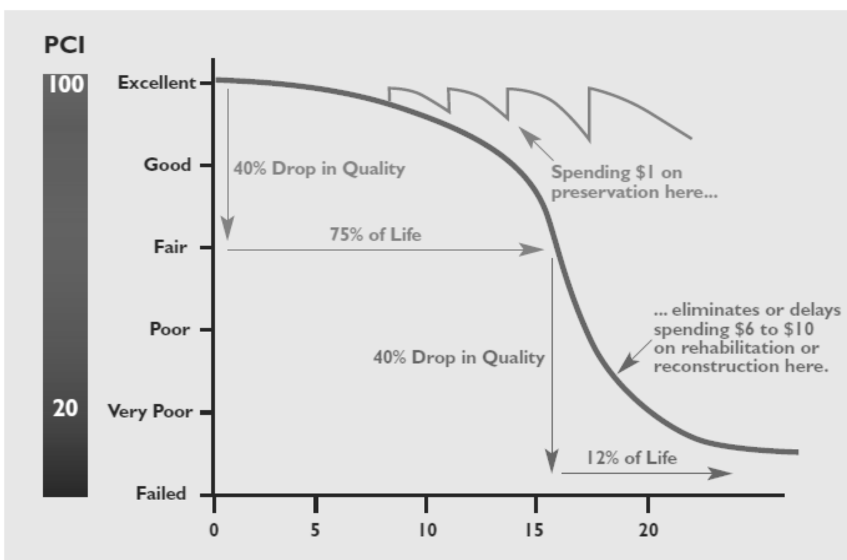

Figure 2. Road deterioration curve (Galehouse et al. 2003)

In this figure, the drop in road quality is eye-catching and serves the purpose of identifying that time plays a key role in pavement preservation strategies. It was critical to point out the difference between preventive maintenance and corrective maintenance (especially in terms of costs and time) and this figure served that purpose.

Nonetheless, pavement preservation could be applied to a pavement in fair to poor condition as a holding strategy. Many agencies will use a slurry seal, fog seal, or crack filling to hold the pavement at its current condition for a short period of time until funding becomes available for a corrective approach.

3Rs of Pavement Preservation

As mentioned before, the first step of pavement preservation is to select the right treatment for the right road at the right time (3Rs of pavement preservation). It is important to understand that to achieve the maximum benefits of pavement preservation these 3Rs need to be achieved along with a proper design and application. Not every treatment will work on every road.

Selecting the right time might be the biggest challenge of the selection phase. Most of the time, engineering judgment plays a key role in determining when to apply such treatments. A recommended measure of treatment timing is to keep track of pavement condition (similar to asset management) and to use a cost approach comparing the cost of delayed maintenance versus early maintenance. In addition, it was critical to point out that pavement preservation is not a once-in-a-lifetime application and that it should be applied routinely.

Selection Process/Tools

It was important to provide trainees with some of the tools available to help in the selection process. Confidence is not easily approached when developing adult training modules, but by providing trainees with more tools for their toolbox, they might feel more comfortable when making decisions. The tools presented are asset management programs, traditional windshield surveys, life cycle cost analysis, and decision matrices.

Asset management refers to the strategic and systematic allocation of resources and funds. The question to be answered is as follows: how are the resources and funds going to be distributed? For example, roads can be categorized by their pavement condition index (PCI) or road condition indicators, thereby providing the agency with information on which roads need corrective treatments and which roads could benefit from a pavement preservation approach.

As the name suggests, a windshield survey consists of having a team of decision-makers drive around a road network and document the current condition of the pavements. One of the primary benefits of conducting a windshield survey is that it provides an actual visual image of the road condition.

Life cycle cost analysis (LCCA) models are intended to furnish pavement managers with measurable failure criteria to estimate service life based on performance (Pittenger and Gransberg 2012). The first cost of the project will influence the decision made on a large scale. Nonetheless an LCCA will provide more information about cost and service life.

Table 2 shows the decision matrix presented in this training module.

Table 2. Decision matrix (Jahren 2007)

Generalized decision matrix for selecting appropriate TMS solutions

Factor		Fog seal	Seal coat	Slurry seal	Micro-surfacing	Thin HMA overlay
Traffic	AADT < 2,000	↑	↑	↑	↑	↑
	2,000 < AADT < 5,000	↑	←→*	←→*	↑	↑
	AADT > 5,000	↑	←→†	←→*	↑	↑
Bleeding		↓	↑	↑	↑	↑
Rutting		↓	↓	↑	↑	↑
Raveling		↑	↑	↑	↑	↑
Cracks	Few tight cracks	↑	↑	↑	↑	↑
	Extensive cracking	↓	↑	↓	↓	↑
	Alligator cracking	↓	←→	↓	↓	↓
Low friction		May improve‡	May improve	May improve	May improve§	May improve
Price ($/yd^2)**		$0.10–$0.80	$0.80	$0.90	$1.50	$4.40

↑ Recommended ↓ Not recommended ←→ Marginal

*There is a greater likelihood of success when used in lower speed traffic.
†Not used in Iowa, but other states have seen success.
‡Fog seal will reduce friction for the first few months until traffic wears binder off of the tops of aggregate.
§Micro-surfacing reportedly retains high friction for a longer period of time.
**Prices were obtained from interviews and anecdotal evidence from author.

This matrix matches the current conditions of a specific road with its most appropriate treatment. For example, say there is a medium volume road (between 2,000 and 5,000 vehicles per day for annual average daily traffic/AADT) experiencing raveling and very few tight cracks. According to Table 2, this road, with its current conditions, would be a good candidate for a fog seal or a microsurfacing application.

Note that this decision matrix is only meant to be used as a reference. Other factors need to be considered when making proper treatment selection. Other factors include cost, material and labor availability, traffic speed, frequency of turning movements, stops, experience, and time.

Road Distresses

This training module goes over six of the major distresses found in pavements. It provides a definition, probable causes, and images. Table 3 summarizes the content included in this module.

Table 3. Distress definitions and causes (Jahren and Plymesser 2007)

Distress	Definition	Cause
Oxidation	Binder becomes brittle and aggregate can be removed easily, light gray appearance	Exposure to sun and water
Raveling	Also known as weathering, binder has worn away	Oxidation, traffic, snow plow
Pocking	Loss of fines	Oxidation
Rutting	Surface depression that runs parallel to traffic, usually in the wheel path	Unstable mix, structural failure, or insufficient compaction
Bleeding	Binder pushed to the surface	Mix rich in binder
Cracking	May run parallel (longitudinal) or perpendicular (transverse) to traffic	Longitudinal – structural failure Transverse – thermal failure

Treatment Introduction

Although introductory presentations were prepared for each of the treatments, the concepting presentation includes a short overview of each treatment. This short overview includes what the treatment is, when to use it, when not to use it, advantages, and disadvantages in a brief manner. For more information on each treatment, the trainee is encouraged to refer to the introductory presentations.

DESIGN TRAINING MODULES

Overview

The goal of the design training modules is to prepare the design staff on the proper design process for each of the treatments. It is important to note that not all aspects of all treatments are designed by the highway or road agency. Instead the contractor or material supplier can be in charge of designing some aspects of a treatment so the result satisfies some aspects of the specifications.

Seven questionnaires were collected and analyzed to format the training modules. The following sections describe the content included in the design training module for each of the four treatments.

Seal Coat (Chip Seal) Design Training Module

Seal coats are commonly designed in-house or by the Iowa DOT. The seal coat training module covers subjects such as material properties and selection (binders and aggregates), aggregate-binder compatibility, design process, and specification review. The following sections provide an overview of the information included in the chip seal design module. The research team encourages readers to refer to the prepared training module for more information.

Asphalt Binders

Two types of binders are commonly used in a seal coat application. Given the use of cutback asphalts has been reduced, the training module focuses more on explaining what asphalt emulsions are, how to classify them, and when to use them, while also mentioning what cutbacks are.

Emulsions are classified by their electrical charge, settling speed, high-float availability, and viscosity. Those emulsions that are positively charged (+) are referred to as cationic emulsions and emulsions negatively charged (−) are anionic emulsions. A cationic emulsion is used more often because the aggregate commonly used for chip seals is negatively charged.

For seal coats, it is common to find rapid-setting emulsions. The reason is that rapid-setting emulsions provide the quickest chip retention. Therefore, less aggregate will dislodge while waiting for the binder to cure.

Another classification is the availability of using a high-float emulsion. High float emulsions contain chemicals that allow for a thicker asphalt layer and are recommended when using dusty aggregates.

Viscosity is another measure when classifying emulsions. Viscosity is designated by the numbers 1 and 2, where 1 is lower viscosity and thereby more fluid. The amount of water in the mix will alter the viscosity of the mix.

The most common emulsion used for chip sealing is a CRS-2, which stands for cationic rapid-setting emulsion with high viscosity. This training module defines each of the classifications mentioned before. As will be seen later, properly selecting which classification of binder to use is critical to have good binder-aggregate compatibility.

This module also presents an animation of how emulsions work, explaining step-by-step how the chip particles, emulsifiers, and binder globules interact.

Aggregates

Understanding aggregate properties and selection is critical when designing chip seals. The aggregate used for chip seals should have certain properties to achieve the best result. In this module, aggregates (chips) are explored with regard to the most important properties to consider when designing chip seals. Images are provided to complement the explanations.

The best type of aggregate for chip seals is a hard, clean, and dust free aggregate. The aggregate will take on large amounts of load and transfer the load to the existing pavement. A soft aggregate will not be able to perform that function well.

The binder will occupy the gaps that are left between aggregate particles. A well-graded aggregate will provide the least amount of voids (top of Figure 3), thereby leaving little space for the binder to settle in between chips.

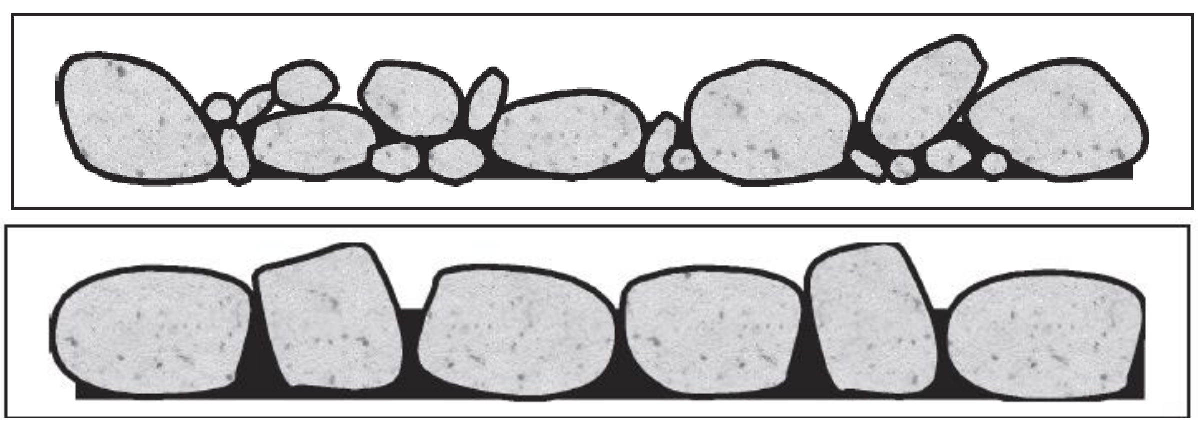

Figure 3. Well-graded versus one-sized aggregate (Wood et al. 2006)

It is commonly recommended to use one-sized aggregates (bottom of Figure 3), but two-sized aggregates are also recommended. Nevertheless, graded aggregate has also performed well. As seen in Figure 3, the use of well-graded aggregate could be more susceptible to chips with little binder adhesion, which can cause “flyrock,” is more difficult to work with, and requires more quality control.

Aggregate shape is another factor to consider. Chips will tend to be oriented to their flat side causing the particles to be submerged in the binder, so a low number of flat particles are preferred. In addition, angular shapes offer better interlocking resistance between them than round shapes, which contributes to their resistance in being rolled and provide more surface area for binder adherence.

Aggregate-Binder Compatibility

The animation mentioned before serves to explain the importance of selecting compatible materials. It is critical to select a binder with the opposite electric charge of that in the aggregate for the binder to adhere to the aggregate properly.

Design Process and Calculations

In a meeting held June 19, 2012 with the design and maintenance staff members, a desire to utilize a step-by-step design process similar to the one described in the Minnesota Seal Coat Handbook instead of relying on previously-determined application rates was expressed. In addition, the questionnaires showed that none of the seven respondents agreed on having knowledge of an actual design calculation process.

At this point, it was decided to develop a separate module that goes through a sample step-by-step design process to obtain application rates for both aggregate and binder (as shown in Table 1).

This report does not summarize the design calculation process because it is summarized in the second seal coat design training module prepared. This module goes over a step-by-step numerical example of a seal coat design.

Specification Review

This module also presents what the specifications determine as appropriate application rates for both aggregate and binder on either single or double coats. It is important for design personnel to be able to review and interpret the specifications. Currently, the Iowa DOT specifications require an aggregate application rate of 30lb/yd^2 and a binder application rate of 35gal/yd^2 (Iowa DOT Specification 2307). The specifications also mention that the application rates provided can be changed by an engineer’s recommendation.

Fog Seal Design Training Module

Unlike seal coats, fog seals are not commonly designed by the Iowa DOT. In addition, a fog seal design consists mostly of selecting a dilution and application rate rather than following a design process. The fog seal design training module focuses more on introducing the materials (mostly emulsions) that can be used for a fog seal and performing a specification review similar to the one that was provided for seal coats.

Materials

A typical fog seal is composed of two primary materials: binder and water. The importance of selecting the appropriate binder is the main focus of this training module. In some cases, sand can also be used to provide a skid-resistant surface and rejuvenators could be added to improve some pavement properties.

Binders used for fog seal projects are normally slow-setting emulsions. The reason for using a slow-setting emulsion is that a fog seal works by penetrating the aged pavement to improve binder properties while providing a sealing and waterproofing layer to prevent further deterioration. The slow set allows more time for penetration.

In Iowa, the two most common types of emulsions used for fog sealing are SS-1 and CSS-1. Both have low viscosity, which aids penetration into the pavement.

Another binder that is sometimes used is a gilsonite seal, commonly referred to as a GSB-88. One significant advantage of GSB is that it prolongs the life of the pavement when compared to traditional fog seals. On the other hand, this application costs more and has been found only in mines located in Utah and Saudi Arabia.

In a pavement preservation conference attended in Nashville, Tennessee in 2012, contractors promoting gilsonite mentioned life prolongation as an advantage of gilsonite. A recent study (Cline 2011) showed that although the initial cost of a GSB application is higher than that of a traditional fog seal, the value of such investment is higher given the life expectancy is higher.

It is highly recommended to use potable water. Potable water reduces the risk of altering the chemical composition of the emulsion. In addition, the correct amount of water is critical as various dilution rates behave differently in the field. Too little water will not decrease the viscosity of the binder sufficiently to penetrate the voids in the surface. Meanwhile, adding too much water will create a highly-fluid mix that may run down cross slopes to the sides of the road.

Specification Review

This module also presents the current specified dilution and application rates for fog seals in Iowa. The current specifications state: “The dilution rate is one part of asphalt emulsion to four parts of water… The diluted asphalt emulsion shall be applied at the rate of 0.12 gal/yd^2 (0.5L/m^2) of pavement surface” (Iowa DOT Specification 2306). The module also presents other dilution and application rates commonly found in the industry for comparison purposes.

Slurry Systems Design Training Module

Slurry systems include microsurfacing and slurry seal. Neither slurry seal nor microsurfacing is designed in-house by the Iowa DOT. The job mix formula is developed through the awarded contractor. However, it is important for the design staff to understand the design process and the tests that are being done to develop the treatment. The slurry system design module contains material selection, developing the job mix formula, and testing.

Material Selection

A typical slurry system treatment contains aggregate, emulsion, mineral fillers, additives, and water. This section of the module covers the parameters for how aggregate can be selected. Particle shape charge, gradation, cleanliness, toughness, and durability are all characteristics of aggregate described in this section. Gradation is an important factor in aggregate selection and this is explained using the sieve test and also by presenting the three types of treatments based on gradation.

The emulsion selection is then done based on the aggregate selection. This part of the module includes visuals describing how an emulsion works and why aggregate charge and gradation is so important for emulsion-aggregate compatibility. Polymer-modified emulsions can be used to improve the treatment characteristics and this is also demonstrated and explained in this section. Tables developed by the National Highway Institute (NHI and FHWA 2007) are also included that show the tests typically conducted on emulsions.

Mineral fillers and additives are described in the module. Examples or what can be used as an additive or filler are included. Mineral fillers are added during design to help promote workability or quicker break times.

Additives can be used by the contractor to help control breaking times when applying slurry throughout a day that has fluctuating temperatures. The module includes all the information necessary to understand what mineral fillers and additives are.

Develop a Job Mix Formula and Testing

In this section, the module walks the trainee through steps required by a lab to develop a job mix formula. The steps include selecting mixing proportions, conducting an abrasion resistance test, determining the upper binder limit, and, finally, determining the optimum binder content. The International Slurry Surfacing Association (ISSA 2010), NHI and Federal Highway Administration (2007), and National Cooperative Highway Research Program (NCHRP) 411 (Gransberg 2010) are all used as references for this process. The module also includes Table 4 showing the tests and the results that should be achieved based on the Iowa DOT specifications.

Table 4. Job mix formula tests (NHI and FHWA 2007)

Property	Test	Micro Surfacing Requirements	Slurry Seal Requirements
Wet-Track Abrasion Loss (Wear Loss)	TB 100 (1 hr soak)	50 g/ft^2 max	800 g/m^2 max
	TB 100 (6 day soak)	75 g/ft^2 max	N/A
Wet Cohesion (Traffic Time)	TB 139 (30 minutes)	10 lb.-in. min	N/A
	TB 139 (60 minutes)	17 lb.-in. min	0.2 kg-m min
Wet Stripping (Adhesion)	TB 114	Pass 90% Minimum	>90%
Classification Compatibility (Integrity)	TB 144	11 Grade Points Minimum (AAA, BAA)	N/A
Excess Asphalt by LWT Sand Adhesion (Excess Binder)	TB 109	50 g/ft^2 max	
Lateral Displacement (Deformation)	TB 147	5% max	
Slurry Seal Consistency, mm	TB 106		30 max (slow set only)
Mix Time	TB 113	Controllable to 120 sec. min	

Specification Review

The Iowa DOT specifications, SS-09003, polymer-modified microsurfacing, and Section 7070, emulsified asphalt slurry seal, have been referenced and reviewed to make sure the design module is consistent. The test results included in this module have been reviewed to reflect the same results outlined in the specifications. Note that all of the information for the module was obtained from the specifications; therefore, the module acts as a supplement to the specifications.

Crack Filling and Sealing Design Training Module

Crack filling and sealing are unlike any of the other three types of surface treatments in that they deal directly and solely with cracks and are commonly a prerequisite to the other treatments. The Iowa DOT will commonly design crack filling or sealing projects in-house. The process is not difficult when compared to designing full-width surface treatments. The module contains information on determining whether a crack is working or non-working (whether to fill or seal), the materials that are available to use, and the placement methods.

Crack Filling versus Crack Sealing

The design staff emphasized in a meeting on June 19, 2012 that they did not feel confident in making a decision on whether to fill or seal a crack. Table 5 shows the information presented in the module to help trainees determine when crack filling or crack sealing should be used.

Table 5. Crack sealing versus crack filling (NHI and FHWA 2007)

Crack Characteristics	Crack Treatment Activity	
	Crack Sealing	Crack Filling
Width	1/4 - 1 in.	1/4 - 1 in.
Edge Deterioration	Minimal to None (<25% of crack length)	Moderate to None (<50% of crack length)
Annual Horizontal Movement	>= 1/4 in. (Working)	< 1/4 in. (Non-working)
Type of Crack	Transverse Thermal Cracks Transverse Reflective Cracks Longitudinal Reflective Cracks Longitudinal Cold Joint Cracks	Longitudinal Reflective Cracks Longitudinal Cold Joint Cracks Longitudinal Edge Cracks Distantly Spaced Block Cracks

It should be noted that the table reflects what is used around the nation. In Iowa, there may be different approaches in determining whether a crack fill or crack seal will be used. When a crack fill or seal project is developed, either all of the cracks are filled or all of the cracks are sealed; there is no distinguishing whether or not it is a working or non-working crack. This table gives a quick guide for making decisions on which type of crack treatment should be selected.

Materials

To support training on material selection during the design process for crack treatments, Table 6 was developed by the NHI and FHWA to show the various materials that can be used.

Table 6. Common material used for crack filling and sealing (NHI and FHWA 2007)

Material	Application Type	Approximate Life (years)
Asphalt Emulsion	Filling	2 to 4
Asphalt Cements	Filling	2 to 4
Fiber-Modified Asphalt	Filling	6 to 8
Polymer-Modified Emulsion (PME)	Filling (minor sealing)	3 to 5
Asphalt Rubber (AR)	Sealing	6 to 8
Specialty AR Low Modulus	Sealing	5 to 9
Silicone	Sealing	4 to 6

The materials given are asphalt emulsion, asphalt cements, fiber-modified asphalt, polymer-modified emulsion, asphalt rubber, specialty asphalt rubber low modulus, and silicone. The table also gives the application type (filling or sealing) that is recommended for the given material and the expected life of the treatment with that material.

The Iowa DOT specifies that only asphalt emulsions should be used for filling and hot-applied sealants for crack sealing. However, Table 6 gives other options that are available beyond those found in the current specification.

Placement Methods

The last section of the module is dedicated to explaining the placement methods that can be used for crack treatments and when to use certain placement methods. There are various placement methods depending on whether the treatment is a crack filling or crack sealing. Crack filling placement methods include flush fill and overband (Figure 4 left), while crack sealing placement methods include reservoir, reservoir with band-aid (Figure 4 right), and sand fill with recessed finish. There is also a visual given to show how backer rod should be used. Each placement method is explained using a visual aid from NHI (2007).

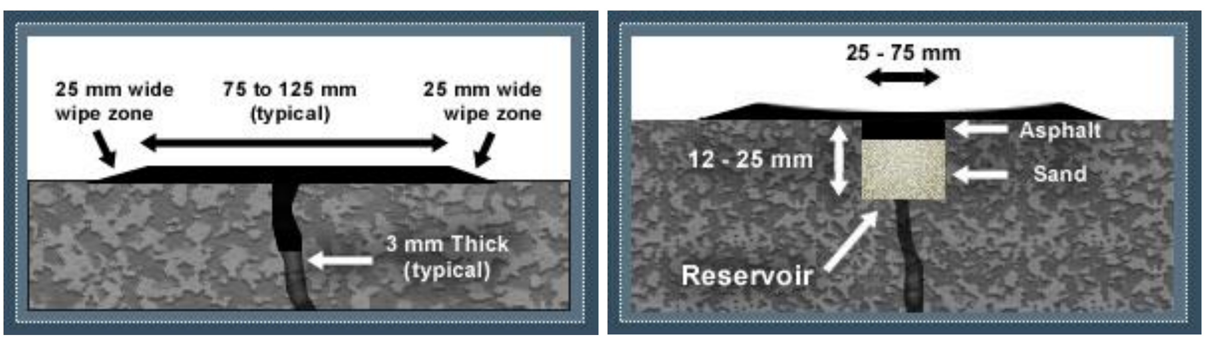

Figure 4. Crack filling and sealing placement methods (NHI and FHWA 2007)

Specification Review

Iowa DOT specifications, Section 2544, cleaning and filling cracks for HMA surfaces, and Section 2541, crack and joint cleaning and sealing (HMA surfaces), were used as a reference for this module. As mentioned earlier, the Iowa DOT specification calls for all crack filling treatments to be asphalt emulsions and for all crack sealing treatments to be approved hot-poured sealer. This was considered and covered in the module, but other material options are also introduced.

The specifications do not mention specific placement methods, but this is included to give the design staff a better understanding of the options that contractors or maintenance forces have for applying crack treatments.

CONSTRUCTION TRAINING MODULES

Overview

The goal of the construction training modules is to prepare the construction staff (mostly inspectors) on the proper application process for the treatments under consideration. A meeting held December 15, 2011 with members of the construction staff was used as an alternative method to using questionnaires to obtain the information required to prepare these training modules due to time constraints. In this meeting, construction staff personnel expressed areas in which pavement preservation treatment applications could be improved and areas that could be incorporated in the training modules.

Seal Coat (Chip Seal) Construction Training Module

Subjects incorporated in the chip seal construction training module include road conditions prior to treatment, pre-application, equipment inspection, equipment calibration, application, post-application, best practices versus poor practices, and troubleshooting. The importance of knowing what to look for before, during, and after the construction process is critical when applying any treatment correctly. Construction staff members mentioned the need to have a standardized process of calibrating equipment. In addition, they mentioned that it would be beneficial to have a section comparing poor practices to good practices with images of aspects they should be looking for.

Conditions Prior to Application

It was important for the training module to state that seal coats do not address major cracks, potholes, or rutting problems so these major distresses need to be addressed some time before the application. In addition, it is common to seal cracks prior to application to prevent the binder from draining into the cracks during application, compromising the ability of the binder to retain chips near the cracks. Minor cracks may not be sealed prior to application but no organic or unwanted material should be present inside cracks. The surface should also be clean and dry. Sweepers are usually used to clean the surface prior to application.

Another aspect to monitor is weather. High winds affect the application process as binder and chips will be blown laterally and not applied uniformly. In addition, if there is a high enough probability for rain, the application should be delayed, as rain water will affect the binder composition and performance. Finally, for the binder to cure properly, the recommended surface and air temperature is above 40°F.

Pre-Application

A good starting point for a seal coat operation is to set up the traffic control plan according to the Manual on Uniform Traffic Control Devices (MUTCD) or specification. Another item to inspect is the aggregate size. If the aggregate in the trucks does not meet the required gradation, the application is likely to be affected adversely.

Utility covers (manholes), if any, need to be covered prior to application. Common materials used to cover manholes and other utilities include cut roofing felt, sand, and plastic. Whichever material is used, the purpose is to cover utilities with a material that is removed easily and will not damage the chip seal application. One more factor to verify before application is the proper function of the equipment (calibration is covered in the next section).

Equipment Inspection

One more factor to verify before application is the proper function of the equipment. The training module shows some of the most important aspects to consider when checking proper function of the asphalt distributor, chip spreader, trucks, rollers, and sweepers.

The spray bar height in the asphalt distributor is critical for achieving a single layer or a double layer of asphalt. If the bar is too low, there's a risk of not covering the whole width of the road; if it is too high, it creates a non-uniform overlapped spray pattern.

Nozzles also need to be checked for proper function. Each nozzle should have no clogs and apply binder at the proper pressure. Clogged nozzles with varying pressures will produce an irregular application. In addition, each nozzle should be set at the same angle to achieve uniform application. Typical angles range from 15° to 30° as seen in Figure 5.

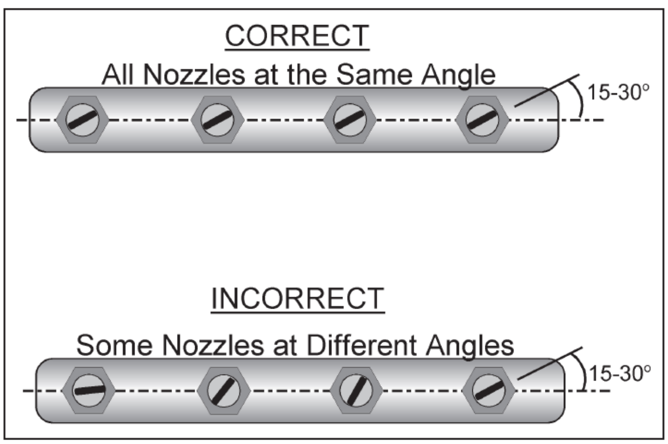

Figure 5. Nozzle angles (Wood et al. 2006)

Gate controls and settings in the chip spreader should be checked to ensure that chips will be spread uniformly. In addition, the truck hookup hitch should be checked to make sure it works properly. A chip seal consists of a continuous application and truck exchanges need to be executed quickly.

Pneumatic rollers are preferred over steel wheel rollers. Two major reasons for this preference are that steel rollers can break aggregate particles, dislodging pieces of them, and pneumatic rollers conform to the shape of the road, applying embedment pressure more evenly despite irregularities. In addition, all tires of the rollers should be inflated to the same pressure so that the embedment will be uniform.

Perhaps the most important factor to understand is that one roller is insufficient. Several studies have identified methods of determining the number of rollers necessary to provide proper embedment while keeping up with the operation (Gransberg et al. 2004; Gransberg and James 2005, Shuler et al. 2011).

Truck boxes should be clean and should only carry aggregate. Most importantly, it is critical to have enough trucks on hand to allow for a continuous application. It is important to check the bristles' lengths in the sweepers. If bristles are too long they can dislodge chips when removing any excess materials. On the other hand, short bristles will not serve the purpose of the sweeper.

Equipment Calibration

As suggested by the construction staff, the construction training presentations show the calibration procedures that are used for the primary equipment. The seal coat construction module provides examples of both a chip spreader calibration and an asphalt distributor calibration.

The chip spreader calibration procedure in the training follows the process described in the Minnesota Seal Coat Handbook (Wood et al. 2006). It begins by spreading chips at the design application rate over 12 by 36 in. rubber mats that extend through the entire width of the chip spreader.

It is critical that the spreader travels at the same speed to be traveled during application. The application should appear one-stone thick. Then, chips on each rubber mat are emptied into one-gallon plastic bags and weighed (Figure 6).

Finally, each weighed bag (converted into pounds per square yard) can alert personnel about when the corresponding gate needs to be adjusted so that the spreader drops the same amount of aggregate satisfying a one-stone-thick layer.

Figure 6. Chip spreader calibration (Wood et al. 2006)

The asphalt distributor calibration process described follows the process described in the NCHRP 680 report (Shuler et al. 2011). For the lateral calibration, containers lined with plastic bags are placed under each nozzle and emulsion is sprayed until containers are approximately 75 percent full. Each weighed container should be within 10 percent of the average of all bags. Adjustments are made if necessary.

For longitudinal calibration, the initial volume of the distributor is measured. Binder is sprayed into the containers used for lateral calibration for approximately 50 ft. When stopped, the final volume is measured. The difference in volume in terms of gal/yd^2 is compared to the design application rate. In addition, this measure should equal the application rate shown in the distributor's computer if using a computer-controlled distributor. This measure should be within 5 percent of the design application rate.

Application

It is critical for the trainee to understand that a proper application is obtained by having a continuous application with the least number of interruptions. The application should look uniform, both transversely and longitudinally. To obtain this uniformity, the application should start and end on a piece of tar paper or roofing paper. If the equipment is calibrated properly, further inspection includes constantly checking for plugged nozzles, having enough trucks in line, having good control of the rollers, controlling the stops and turns, and making sure the distributor and spreader match speeds.

Post-Application

It is important to have properly working sweepers to ensure that any excess aggregate is removed from the surface. After the surface has been properly swept, markings can be placed on top of the chip seal. It is a common practice to apply a fog seal application (sometimes called a dust coat in

Iowa) after a chip seal (normally the next day) as this will not only create stronger chip retention but also provides a dark background for road markings.

All construction-related signs should be changed to speed reduction signs when opening the road to traffic. It is critical to manage the opening time effectively. Early opening will create aggregate dislodgment problems.

Poor Practices versus Best Practices

As mentioned before, the construction staff found it helpful to have visual images of best practices and poor practices. These images will help them identify how a proper treatment should look and practices to avoid. Each poor practice image is accompanied by an explanation of what has been done poorly. The research team encourages readers to refer to the seal coat construction training module for examples of best practices and poor practices.

Troubleshooting

This section presents many of the issues that could occur during application and ways to remedy them. The training module does not provide trainees with all possible issues and remedies, but it does provide an external reference (NHI and FHWA 2007) for a more complete list of issues and remedies. Please refer to the training module for an example of the issues and remedies presented.

Fog Seal Construction Training Module

Subjects incorporated into the fog seal construction training module are related to those included in the seal coating module. The following subjects are similar to those in the previous subsections of this report and are not repeated below: Conditions Prior to Application, Pre-Application, Equipment Inspection (asphalt distributor), Application, Post-Application, Poor Practices versus Best Practices, and Troubleshooting. For information on the minor differences, please refer to the fog seal construction training module.

Equipment Calibration

Although the asphalt distributor calibration procedure presented in the seal coat section is applicable, this training presentation follows an alternate method. The asphalt distributor calibration presented follows the steps in the Pavement Preservation Treatment Construction Guide (PPTCG) (NHI and FHWA 2007).

The process starts by weighing a 1yd^2 mat and laying it on a road segment. The next step is to apply the fog seal over it and weigh the mat again. The difference in weights provides the weight of binder per square yard, which then is converted to gal/yd^2. This number is then verified against the specified application rate and adjusted accordingly.

Water Testing

In the case that water needs to be added to the mix, it is important to select the right type and quantity of water. Although the term “type of water” might seem eccentric, not any type of water can be added to a fog seal mix. The water is not only recommended to be potable, it also needs to be compatible with the mix. The PPTCG provides a method for determining if the water to be added will be compatible with the fog seal mix (NHI and FHWA 2007).

The process starts by mixing the emulsion and the water in a one liter can. The mix is stirred for about two to three minutes. The resulting mix is then poured through a pre-wetted 150 mm sieve. If more than 1 percent of material, by weight, is retained on the sieve, the water is not compatible, has altered the chemical composition of the emulsion, and should not be used. This process is commonly called a sieve test (Figure 7).

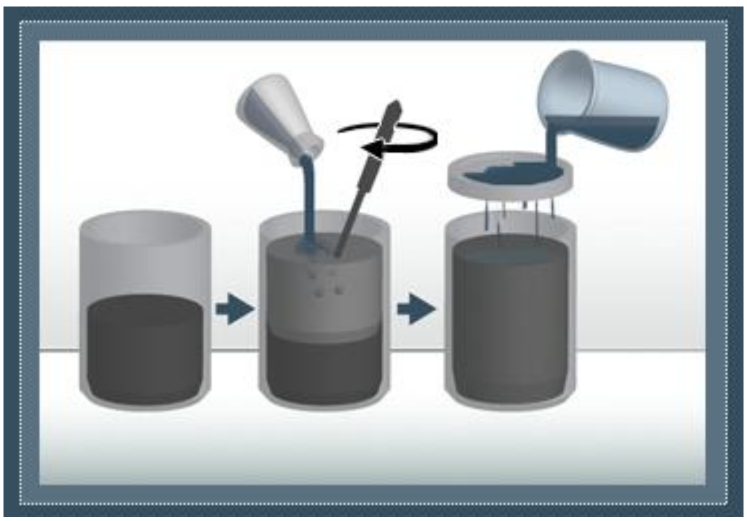

Figure 7. Water testing procedure (NHI and FHWA 2007)

Slurry Systems Construction Training Modules

The construction staff emphasized a great need for a module providing information on the inspection of slurry system projects; specific surface preparation, equipment calibration, and inspection points. To keep training modules short and to the point, this one was broken into two parts. The first module covers pre-application subjects such as conditions for application, pre-application general preparation, pre-application surface preparation, and equipment calibration. The second module covers application and post-application subjects such as application types, application rates, inspection points, special conditions, checklists, and trouble shooting.

Pre-Application Environmental Conditions and General Preparation

The first thing to consider when applying a slurry system is the environmental conditions. If the weather is not favorable, the treatment will not perform. In this module, conditions such as temperature, weather (rain), and time of day are discussed in terms of how they can affect slurry system treatments.

Even before the weather becomes a factor, the contractor and inspector should be thinking about site planning and logistics. Items that should be considered and included in plans are traffic control, stockpile location, and local community notification (which is not required by Iowa DOT specification but it is a good practice). The inspectors should be sure the contractor has a sufficient traffic control plan and that their stockpile is in a close, easily-accessible area that does not pose a material contamination threat.

Surface Preparation

Before a slurry system treatment is applied to a road, it is a crucial for the existing surface to be prepared properly. This can be one of the most important steps in applying a slurry system. In this module, the presentation highlights surface cleaning.

It is emphasized how the existing surface should be treated for cracks and base failures. If these treatments are already completed, the surface should be thoroughly cleaned to remove all dust, vegetation, grease or oil spots, and any other objectionable matter. To help explain the importance and reasons for cleaning the surface, the module includes a slide explaining how an emulsion works and how the presence of dust can cause problems.

As a part of surface cleaning, the inspector should be sure to check if all pavement markings have been handled correctly. Three types of pavement markings are mentioned and ways to handle each type are explained. Once the surface has been cleaned thoroughly and pavement markings are addressed, the inspector needs to be aware of how to handle protection of existing structures such as manhole covers. The process for completing this, along with suggested strategies are included in this portion of the module.

In the last portion of the surface preparation section, scratch coats and pavement pre-wetting are mentioned. The inspector should understand that sometimes a slurry system treatment may need a leveling scratch coat before the top surface is laid down. In addition, as a final surface preparation check (could also be included in the equipment inspection), the inspector should make sure the machine is pre-wetting the surface at a desired rate. The details of this and a visual are included in this module.

Equipment Calibration

The final section of the pre-application module is dedicated to equipment. Examples and visuals of the equipment commonly used for both microsurfacing and slurry seals are presented. Then, the equipment calibration theory and procedures are explained, including test strips. Images such as the one shown in Figure 8 are provided to educate or refresh an inspector on the various components of the equipment that are involved in the calibration process.

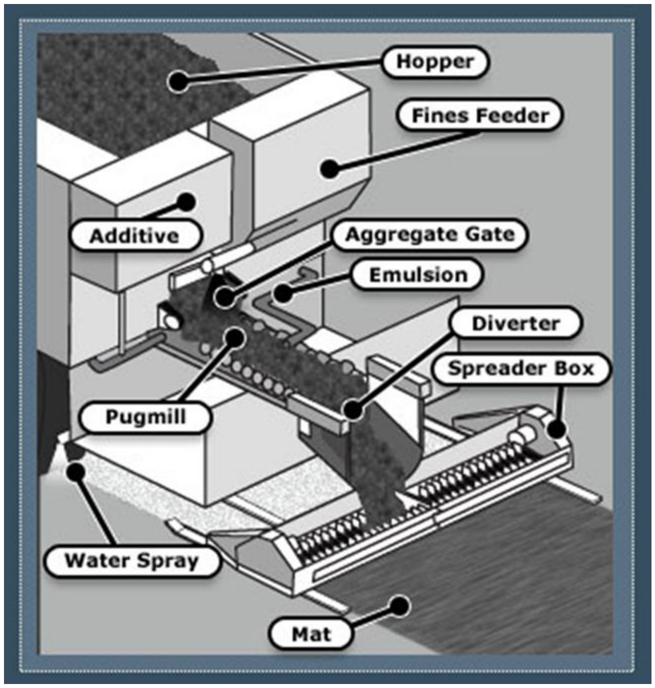

Figure 8. Components of a continuous spreading machine (NHI and FHWA 2007)

There is also an example of a step-by-step procedure in table format given for reference (see Table 7). Equipment calibration concludes the first part of the slurry system construction module.

Table 7. Calibration procedures for microsurfacing (ISSA 2010)

	Asphalt Emulsion Calibration Procedure
1	Connect the production emulsion pump output to a container
2	Run the pump long enough to fill the connection hose with emulsion to ensure all runs are the same
3	Zero the counter before each run
4	Pump a large enough sample of emulsion on each of three runs to ensure the accuracy will be 2% or better. The sample size is calculated by dividing the accuracy of the scale by 0.02. *For Example, if weighing the emulsion sample in a barrel on a platform scale with an accuracy of ± 1 pound, the minimum sample needs to be 50 pounds (1 lb/0.02).* Determine the net weight for each run by weighing either the placement machine (on a truck scale) before and after the run or weighing the emulsion pumped (on a platform scale). Divide the net weight pumped by the number of counts of the rock/aggregate belt for the three test samples and record the pounds per count for each
5	Average the pounds per count of the three runs
6	The placement machine should deliver such volumetric consistency that the deviation for any individual emulsion run shall not exceed 2% of the mathematical average of three runs
7	The average pounds per count results will be used in the gate setting calculations

Application Types and Rates

To begin the second part of this construction module, the various types of applications are mentioned briefly and discussed. Full-width, scratch coat, rut filling, and patching are the application types included. The next portion of the module is dedicated to application rates and which factors can influence the rate.

Aggregate gradation, existing surface texture, and mix moisture content are all mentioned and discussed. Along with the explanation, a table showing the factors influencing application rates from ISSA (2010) is included to give trainees a more structured reference.

Inspection Points and Special Conditions

The next part of the module goes through the types of things an inspector should look for during application. These are called the inspection points and they include longitudinal joints, edge lines, transverse joints, structures, texture, early traffic damage, and smoothness or ride quality. Visuals such as Figure 9 and an explanation of each inspection point are provided.

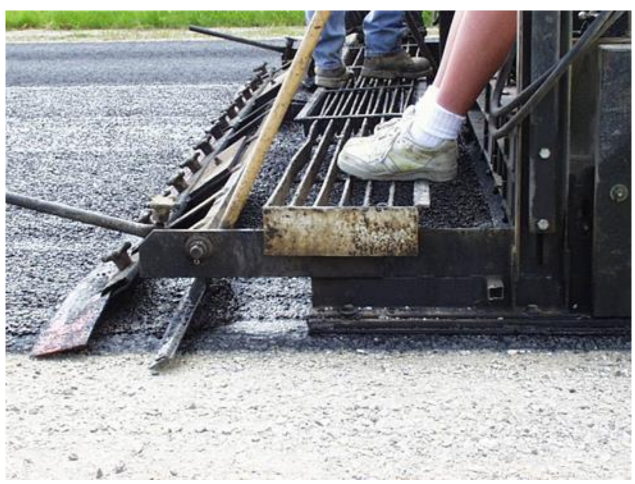

Figure 9. Inspection point - edge lines (ISSA 2010)

The module also includes a slide for special conditions. Multiple lifts (microsurfacing), cul-de-sacs, and high quarter crown roads are the three common special conditions covered in this module.

Checklists and Troubleshooting

At the end of this module, links are provided that lead to the NHI website. This website has construction checklists and problem resolution tables. The checklists can be very helpful in ensuring the inspector covers everything before and during the project. The problem resolution tables can help explain problems that have already occurred and can help prevent problems.

Crack Seal/Fill Construction Training Module

Because the Iowa DOT has sufficient experience doing crack filling and sealing, this module was developed with the intent not to present new information, but to give an overview to refresh the memories of the construction staff. The subjects included in this module are conditions for application, equipment, the overall process for construction, and poor practices, checklists, and troubleshooting. Within the overall process for construction the following topics are discussed: traffic control and safety, crack cutting, crack cleaning and drying, material preparation, material placement, and finishing.

Conditions for Application and Equipment

Before the overall process of construction is explained, there is a brief overview of the conditions for application and the equipment used on a crack filling or sealing project.

The conditions for application are not as strict when compared to other treatments. It is recommended to complete the treatments in the spring or fall, but much of the temperature factor depends on the material being used.

For the equipment portion, crack cutting equipment, cleaning equipment, equipment for hot-applied sealants, equipment for other application types, and finishing equipment are briefly illustrated and explained.

Construction Process

The construction process for crack filling and sealing includes six steps: establish traffic control and safety, crack cutting (if needed for crack sealing), crack cleaning and drying, material preparation, material placement, and finishing.

Traffic control and safety is included as a reminder to construction staff, first and foremost, to be safe and have a plan.

The crack cutting step is only needed if the treatment is crack sealing. Cracks can be either cut or routed and examples are given and explained in this module. Crack cutting is used when the crack is uniform because the process can yield a smoother edge. If the crack is not uniform and not easily maneuverable by diamond blade, a router should be used. When performing a cut or routing, it is emphasized that the existing condition of the material surrounding the crack should be checked to see if a cut can be performed without spalling.

Crack cleaning and drying is a very important step in the construction process. If the crack is not cleaned thoroughly, the material, whatever is used, will not adhere properly. This section of the module describes each method that can be used for cleaning a crack. The Iowa DOT specification calls for either air blasting or water blasting and both are included in this module along with other options. Figure 10 shows an example of a visual used in this module.

Figure 10. Crack clean by air blasting

The material preparation and placement portions of this module are focused more on the placement, but the heating temperatures, placement temperatures, and other guidelines are included as a reminder for the construction staff to be sure to check them.

Eight different placement methods are illustrated and explained. It is also explained which methods are used for filling and which are used for sealing. Standard good placement practices are provided as a part of the material placement portion of this module.

The most common types of material used for filling and sealing cracks are emulsions and hot-applied rubber. An individual slide is provided explaining emulsions and hot-applied rubber in more detail.

The final step in the construction process is finishing. Over-banding, sanding, and blotting are illustrated and explained in this part of the module.

Poor Practices, Checklists, and Troubleshooting

The final part of the module is dedicated to providing the trainee with visuals of poor practices and other tools for proper construction. Similar to what is provided for slurry system construction, the construction checklist is provided to help ensure construction staff has covered every aspect of the project.

In addition, the same type of problem resolution tables are provided as a tool for resolving issues after the fact or preventing issues prior to construction. In addition to the problem resolution tables, a table of common problems is provided.

MODULE IMPLEMENTATION

Each of the modules described and outlined in the Introduction (Table 1) are prepared and ready for implementation. As mentioned previously, it has been determined that there will be two methods of implementing and using the modules for training: short face-to-face meetings with online references and short, on-demand online reference modules.

The concepting and design staff divisions are structured for implementing the short face-to-face meetings with online references. To implement this method, an individual is needed to organize and run an annual meeting with each staff division. In this face-to-face meeting, the participants can work through each module and discuss and share experiences on the various topics included.

The slides that have been developed will be made available for editing and changes can be made as the meeting is conducted. After the meeting concludes, the resulting set of slides or modules will be uploaded to a specific location on the Iowa DOT website for reference throughout the year.

The research team found that the construction staff operates differently than the concepting or design staff. An annual face-to-face meeting may not be feasible with the construction staff. Because of this, it was determine that the construction modules would be pre-recorded and made available online for quick reference. The construction module slides will also be made available to the Iowa DOT so information can be revised and the modules can be re-recorded and made available after that.

LESSONS LEARNED AND CONCLUSIONS

- The questionnaires were an effective way to help determine which type of information should be emphasized in the modules, but it was found that the questionnaires should not be the only means of obtaining information.

  The project team found the face-to-face round table discussions to be very beneficial not only for obtaining information, but also for validating material in progress. It was determined that when doing qualitative research such as this, the best information can sometimes be obtained via informal round table discussions. (However, this can be more difficult to document and prove that it is useful without quantitative data.)

- The methodology used for this project fit the framework of qualitative research very well. The fusing of the job training structure and action research gave the project team the ability to develop a sophisticated training structure effectively while still having the ability to validate the material in a cyclical process.

- The LMS developed contains the information and tools to educate Iowa DOT staff, but there needs to be an initiative to implement the system fully and to start to make a change. Otherwise, the LMS will not be effective.

- A telephone survey of other state agencies was conducted and the feedback was positive on the use and practicality of the developed LMS. These results indicate that the research conducted is not only useful for the Iowa DOT, but that the process can be used by other agencies to help implement more effective pavement preservation programs.

- The LMS developed still needs to be implemented for use by the Iowa DOT to ensure it achieves the intended objective successfully. One of the positives of the resulting material is that it can be modified and streamlined for use in the coming years. This LMS provides a framework for the Iowa DOT to work with to help promote a more successful pavement preservation program.

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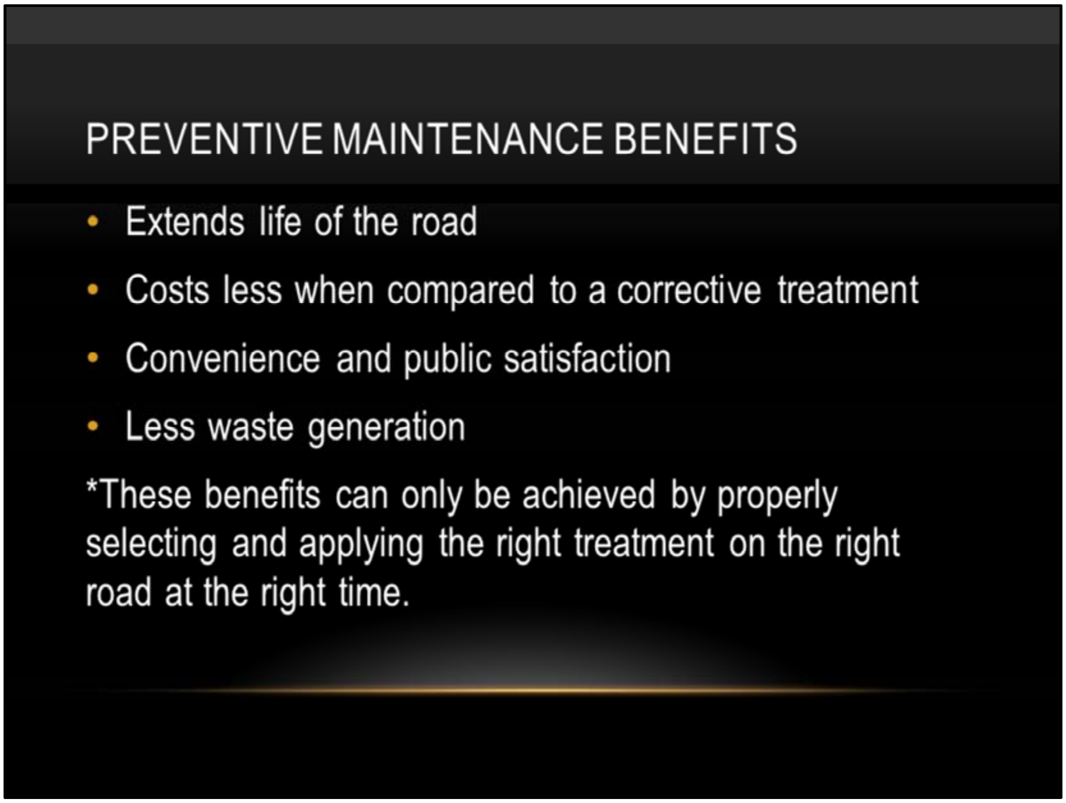
PREVENTIVE MAINTENANCE: CONCEPTING



Let's remember that preventive maintenance does not add structural value to the road, it simply keeps the road in good condition for an extended period of time.

If we were to skip preventive maintenance and let the road deteriorate over time, a point will be reached where the approach necessary to deal with the road is a corrective treatment. A corrective treatment can be compared to building a new road.

As users we want to get from point A to point B in the most convenient way possible. Preventive maintenance could provide users with a smooth ride and less car/tire deterioration.

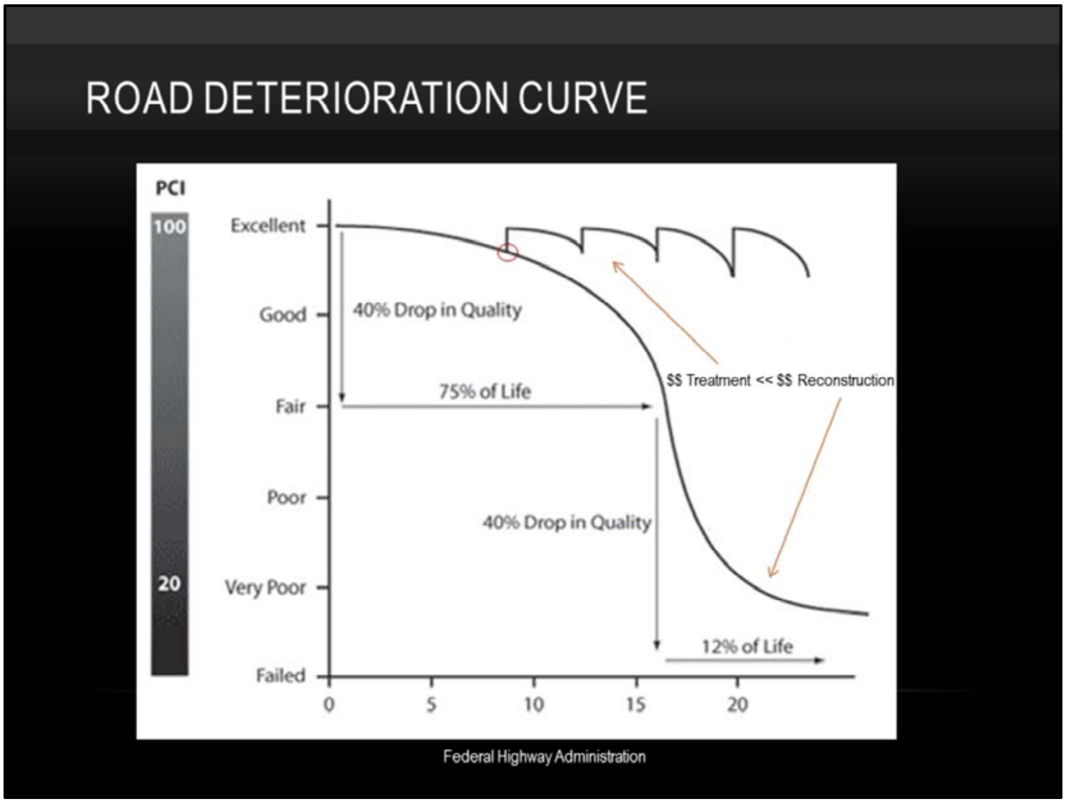

IMPORTANCE OF CONCEPTING TRAINING
Training should help you:
Understand the overall road selection process
Identify road deteriorations and/or conditions that make a road a good candidate for preventive maintenance
Explore the different alternatives or treatments for road maintenance depending un such conditions
Value the importance of selecting the right treatment for the right road at the right time

What is it

- Preventive Maintenance is like painting your house. It doesn't add any structural integrity but it gives the house a better surface and helps prevent major deterioration. In the same way, if you paint a house that is near falling down, the paint won't stop it from doing so.

Why use it

- Remember that the reasons we want to use preventive maintenance is because of the added benefits, but if preventive maintenance is not properly done the benefits are non-existent. Using preventive maintenance in the wrong way can actually be worse than doing nothing at all.
- With that said, when done correctly, a preventive maintenance adds many benefits to the users. The two most important are prolonging the lives of good roads and cutting down costs. There are also other benefits such as public satisfaction, public convenience, and, in some ways, sustainability.



- This illustration is a typical road deterioration curve. Each road is different in terms of the increments of time it takes to deteriorate, but all roads follow this characteristic curve.
- You can see the benefits I mentioned early. The road's life can be prolonged using treatments while saving money in the long run.
- As we will talk about later, the hardest part is finding the right time to apply the treatment before the road drops off.
- If a treatment is applied after the road has substantially deteriorated then the treatment application is considered more of a corrective maintenance than a preventive maintenance. (i.e. a slurry system will usually hold for 5-7 years but it could be placed on a very poor road and only hold it together for 1-2 years, giving the department time to find funding for reconstruction)

- As discussed earlier, in order to achieve the maximum benefits of preventive maintenance it must be incorporated properly.
- Finding the Right road, applying the Right treatment at the Right time are the key ingredients to a successful preventive maintenance.
- Each of the 3R's go hand in hand.
- Throughout the rest of this presentation best practices for selecting roads will be discussed.

<u>Asset Management</u>

- You already be using it, but it may not be called asset management. Each and every agency has their own method of asset management.
- We are calling it asset management because you are allocating resources and funds to correct and/or maintain roads, which are a majority of an agencies assets (other assets are signs and bridges)
- When selecting a road the following characteristics are commonly considered in asset management programs:
    - Pavement Condition Index (PCI
    - Traffic Volume (AADT)
    - Traffic Velocity
    - Road Classification (Primary, residential)
    - Proximity (# of business, # of residencies)
    - Budget (how much do you have to spend?)

<u>Windshield Survey</u>

Driving around roads for which the agency is responsible for
Document the conditions of roads
From survey information they determine which roads will require a preventive maintenance treatment

<u>Life Cycle Cost Analysis</u>

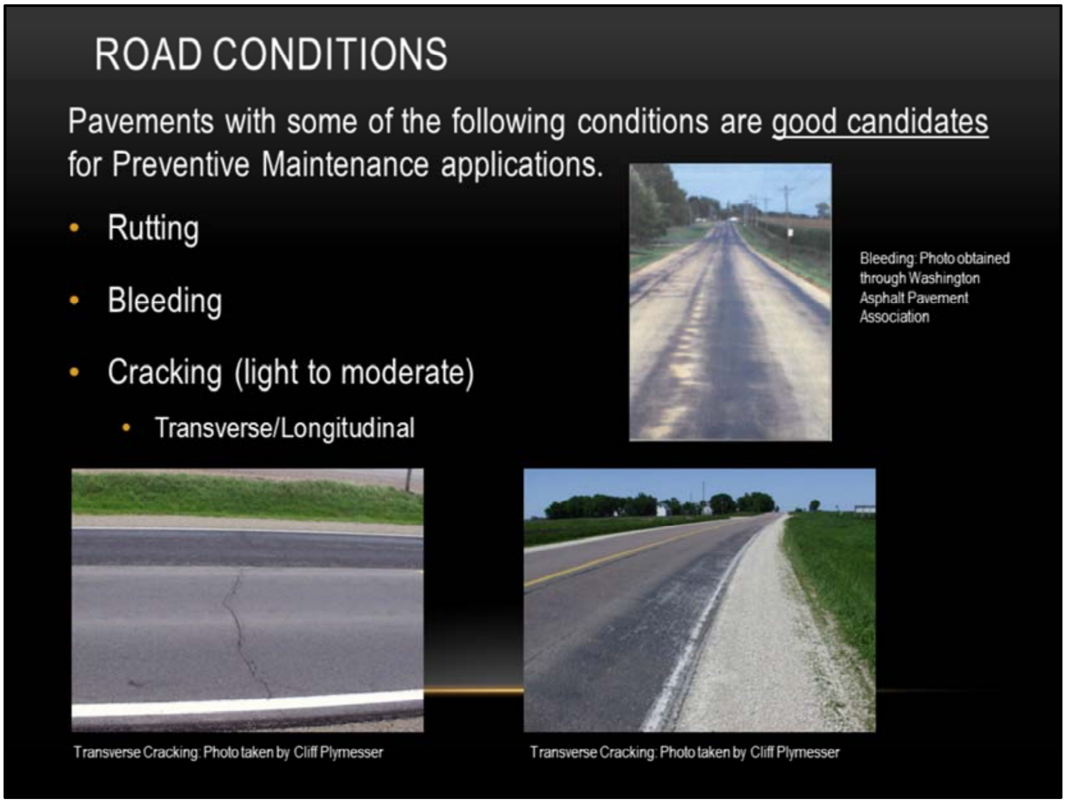
It is important to consider the cost of the possible applications.

More than that, it is recommended to consider the life cost of such treatments. Treatments have different lifespans, so considering the equivalent annual cost of available treatments is a better interpretation of the real cost-benefit ratio.

Oxidation – caused by exposure to sun and water, binder becomes brittle and aggregate can be easily removed. Surface of pavement is light gray.

Raveling – also known as weathering, aggregate or binder has worn away due to oxidation, traffic, snow plow (picture)

Pocking – individual pieces of aggregate have dislodged from the surface leaving small voids.



Rutting – a surface depression that runs parallel to traffic and is commonly located in the wheel path. Rutting can be caused by unstable mix, structural failure or insufficient compaction during construction. (picture)

Bleeding – occurs when asphalt binder is pushed to the surface providing a shiny black appearance. Mix was too rich in binder.

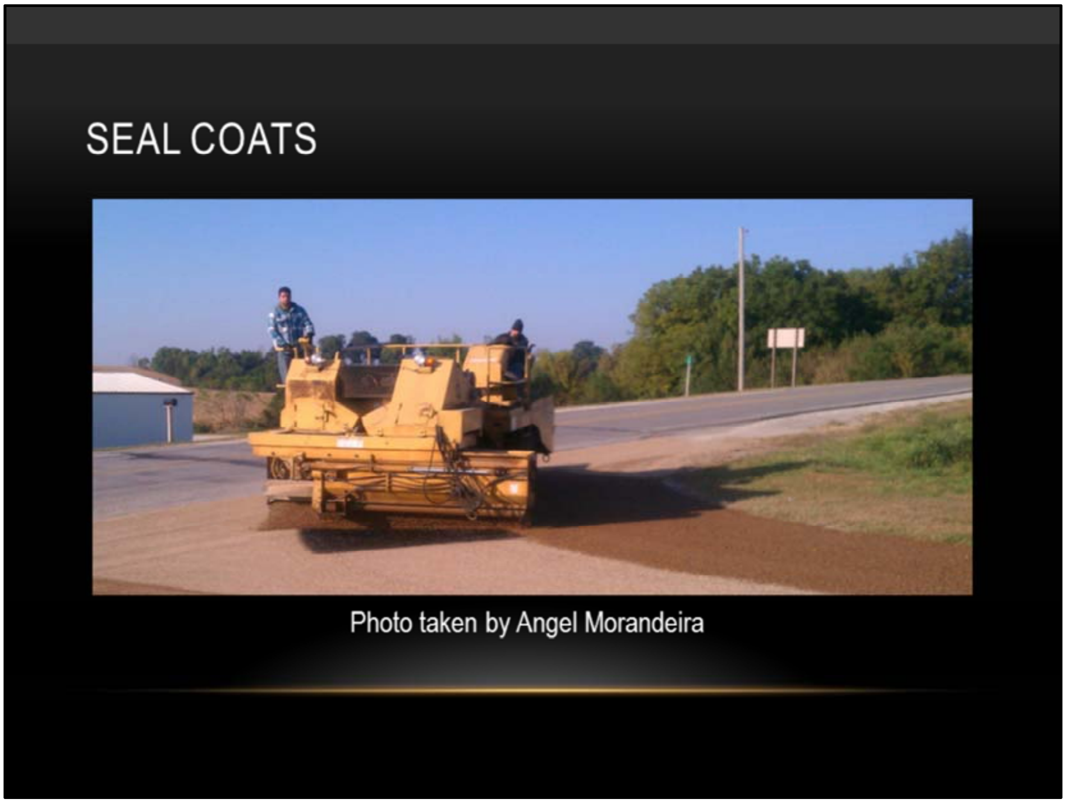
Longitudinal cracks – run parallel to traffic and indicate structural failure.
Transverse cracks – perpendicular to traffic and indicate thermal shrinkage. (picture)
Alligator cracking – interconnected cracks that resemble alligator scales, usually forms in areas of high volume loads.

Seal coats – also called chip seal. Seal coat is an application of binder followed by an application of single sized aggregate chips. Seal coats are typically used in low volume roads. They provide surface waterproof and seal existing cracks while adding friction for traction. Disadvantages - They may cause dust, flyrock and noise.

Fog seals – this treatment consists of a light application of binder to the pavement. They serve to seal the surface and prevent distresses as oxidation and raveling. Disadvantages - Fog seal takes time to cure (6-8 hours) and provide low friction. Fog seals are commonly paired with seal coats to provide stability and minimize the amount of dust and flyrock.

Slurry Seals/Microsurfacing – Slurry seals and microsurfacing are very closely related. They only differ in how they cure; slurry seal cures via evaporation while microsurfacing cures through a chemical reaction known as breaking. Microsurfacing and slurry seals can be used to seal surfaces, restore texture, fill cracks and ruts, and level a surface. Disadvantages – There is a longer wait time until driving is permitted when compared to seal coats. Also microsurfacing is one of the most expensive preventive maintenance treatments.

Crack seals/fills – Crack Filling and Sealing prevents water and incompressible intrusions, improves ride quality, slows down pavement deterioration, is cost effective, and is essential in the preventive maintenance process. Roads need to have there cracks filled or seal before a seal coat or microsurface can be applied. Disadvantages – Crack filling and sealing only effects a small part of the road and cannot be used to improve the entire surface. This is why other treatments need to be used with crack filling and sealing.



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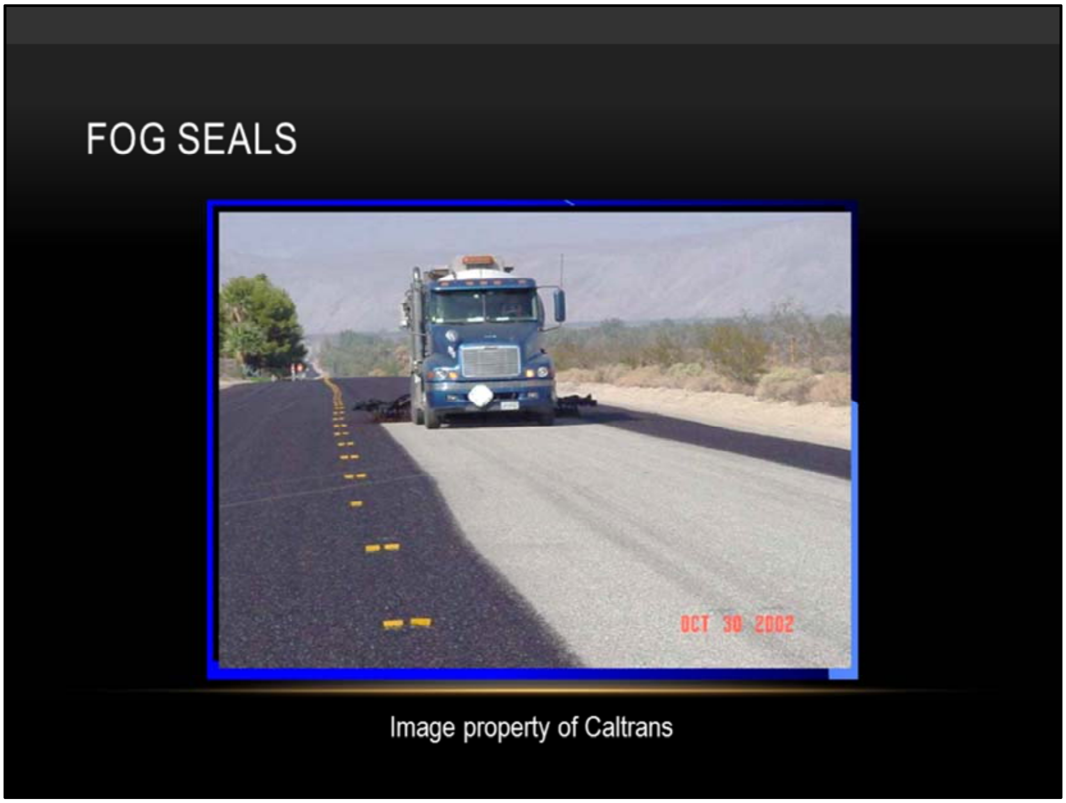

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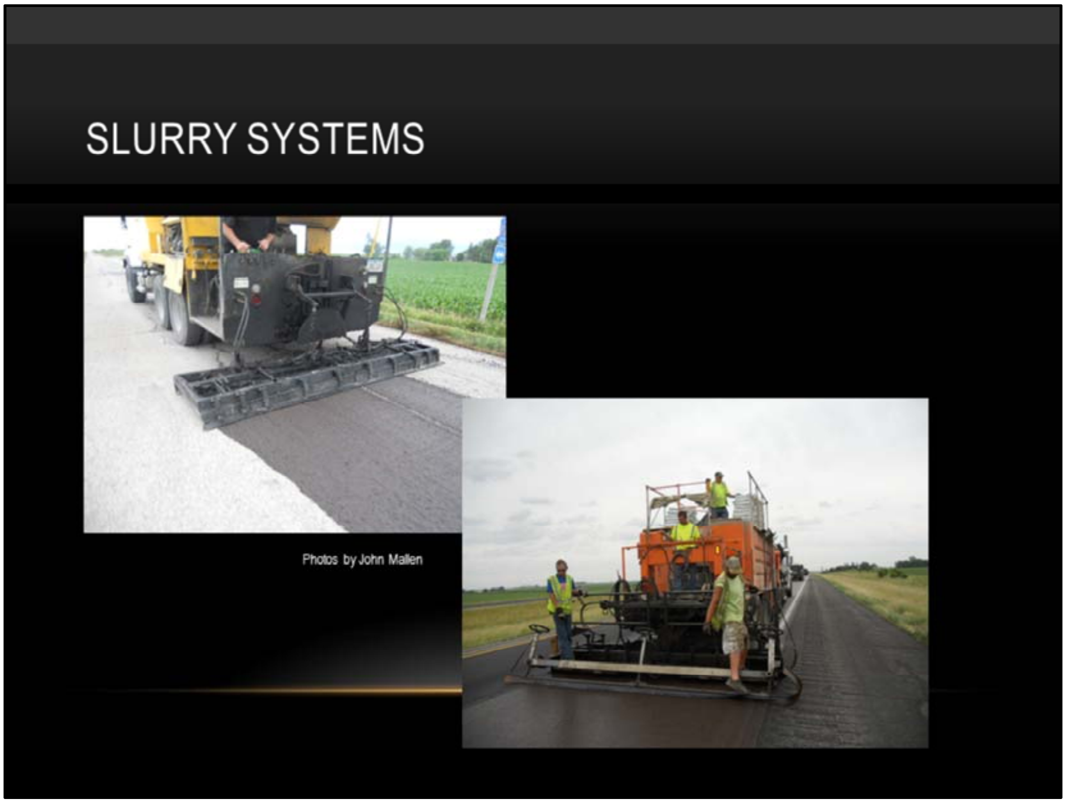
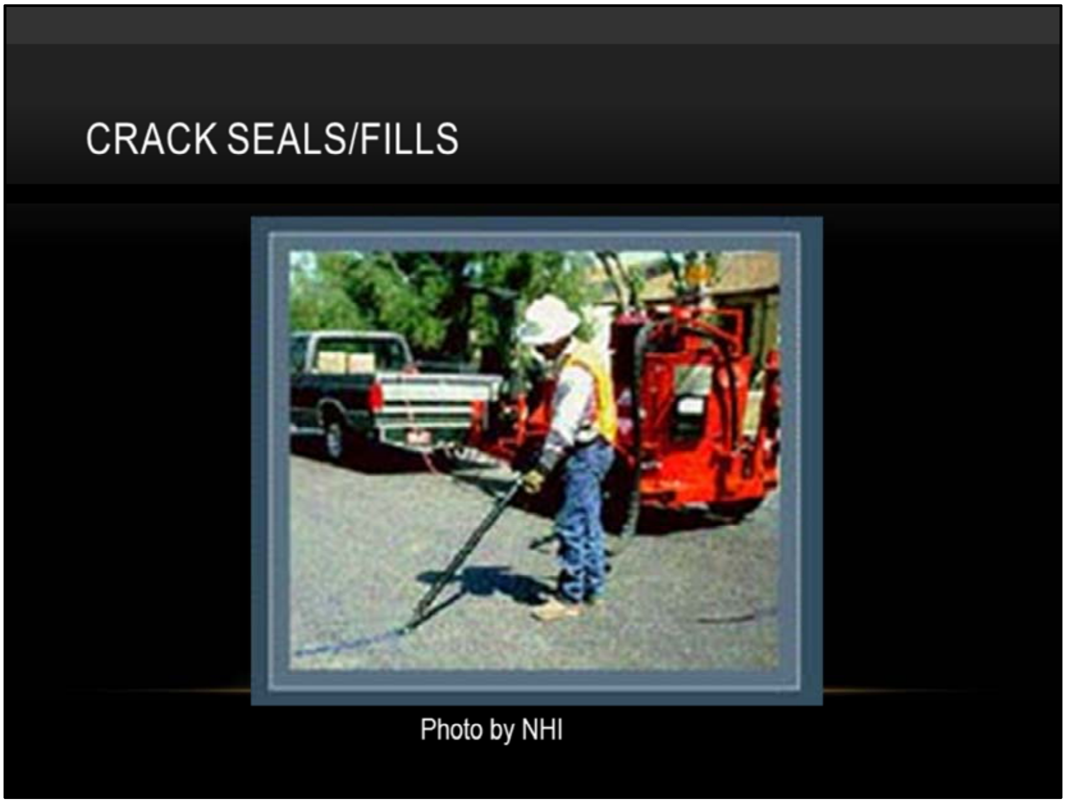


Slurry Seals/Microsurfacing – Slurry seals and microsurfacing are very closely related. They only differ in the number of lifts they can be applied in and also how they cure; slurry seal cures via evaporation while microsurfacing cures through a chemical reaction known as breaking. Microsurfacing and slurry seals can be used to seal surfaces, restore texture, fill cracks and ruts, and level a surface. Disadvantages – There is a longer wait time until driving is permitted when compared to seal coats. Also microsurfacing is one of the most expensive preventive maintenance treatments.



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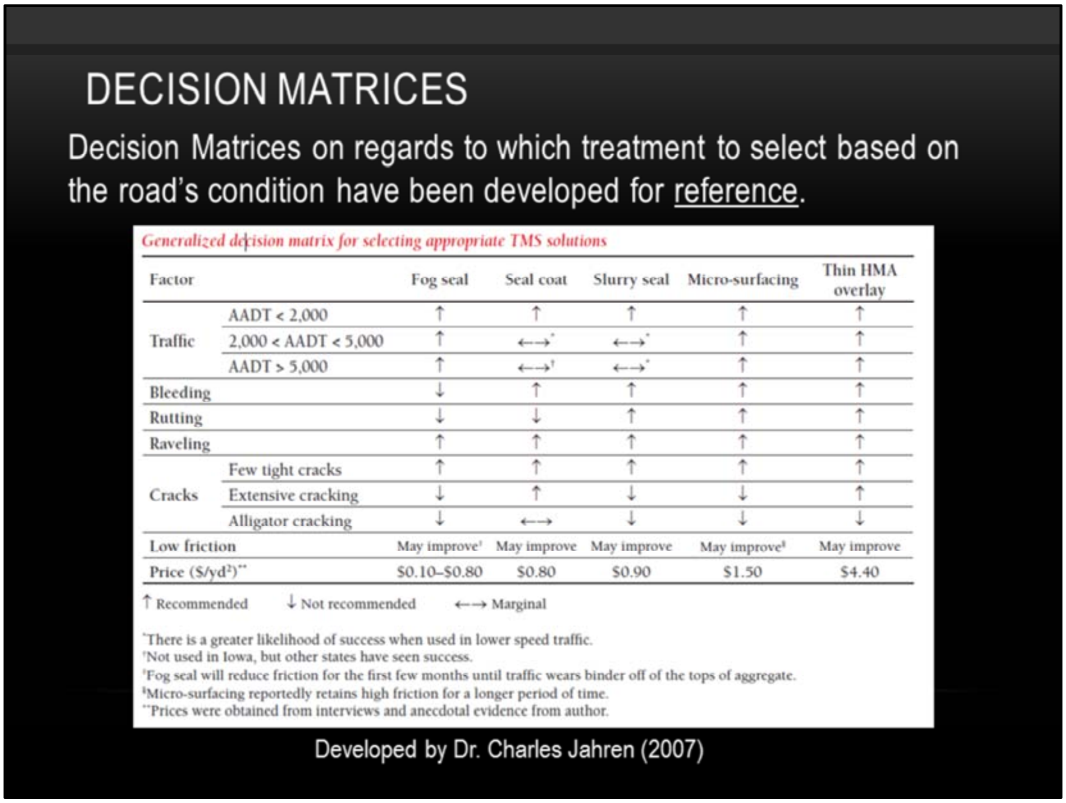


Generalized decision matrix for selecting appropriate TMS solutions

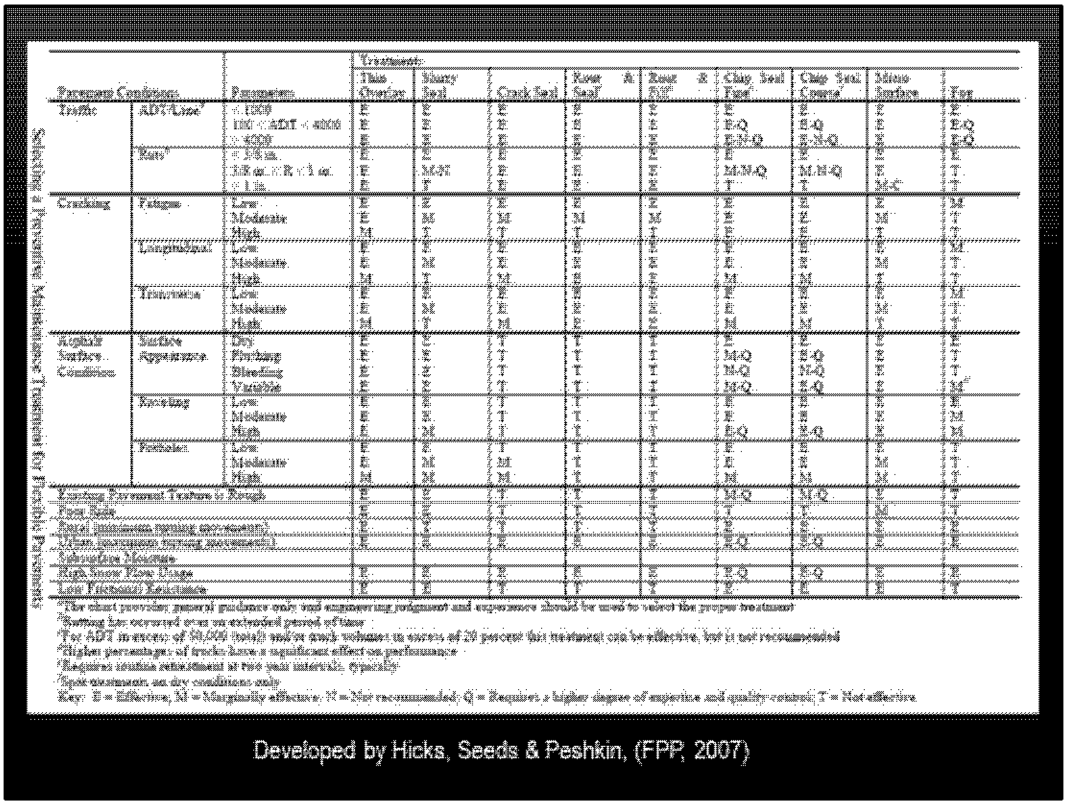
Factor		Fog seal	Seal coat	Slurry seal	Micro-surfacing	Thin HMA overlay
Traffic	AADT < 2,000	↑	↑	↑	↑	↑
	2,000 < AADT < 5,000	↑	←→[*]	←→[*]	↑	↑
	AADT > 5,000	↑	←→[†]	←→[*]	↑	↑
Bleeding		↓	↑	↑	↑	↑
Rutting		↓	↓	↑	↑	↑
Raveling		↑	↑	↑	↑	↑
Cracks	Few tight cracks	↑	↑	↑	↑	↑
	Extensive cracking	↓	↑	↓	↓	↑
	Alligator cracking	↓	←→	↓	↓	↓
Low friction		May improve[‡]	May improve	May improve	May improve[§]	May improve
Price ($\$/yd^2$)[**]		\$0.10–\$0.80	\$0.80	\$0.90	\$1.50	\$4.40

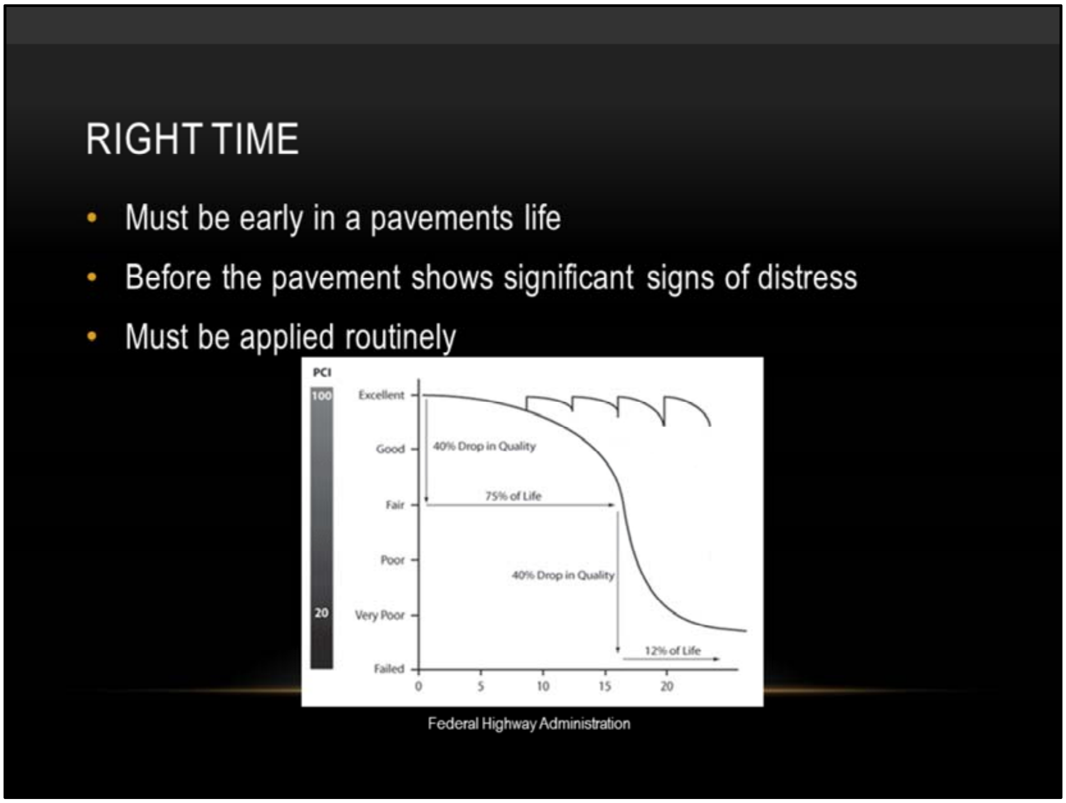
↑ Recommended ↓ Not recommended ←→ Marginal

[*] There is a greater likelihood of success when used in lower speed traffic.
[†] Not used in Iowa, but other states have seen success.
[‡] Fog seal will reduce friction for the first few months until traffic wears binder off of the tops of aggregate.
[§] Micro-surfacing reportedly retains high friction for a longer period of time.
[**] Prices were obtained from interviews and anecdotal evidence from author.

Tendencies on regards to what treatments have been used depending on road conditions have been observed. Researches and professionals have developed decision matrices or decision trees that can be used as a reference on helping someone decide which treatment fits best. It should be noted that these are only for REFERENCE and do not have to be followed strictly. The decision should not only be based on road condition as cost, experienced labor availability and aggregate availability may also influence the decision.

Say you had a road with 3,000 AADT, few tight cracks, and raveling. According to this matrix a fog seal and a micro are recommended.


Developed by Hicks, Seeds & Peshkin, (FPP, 2007)

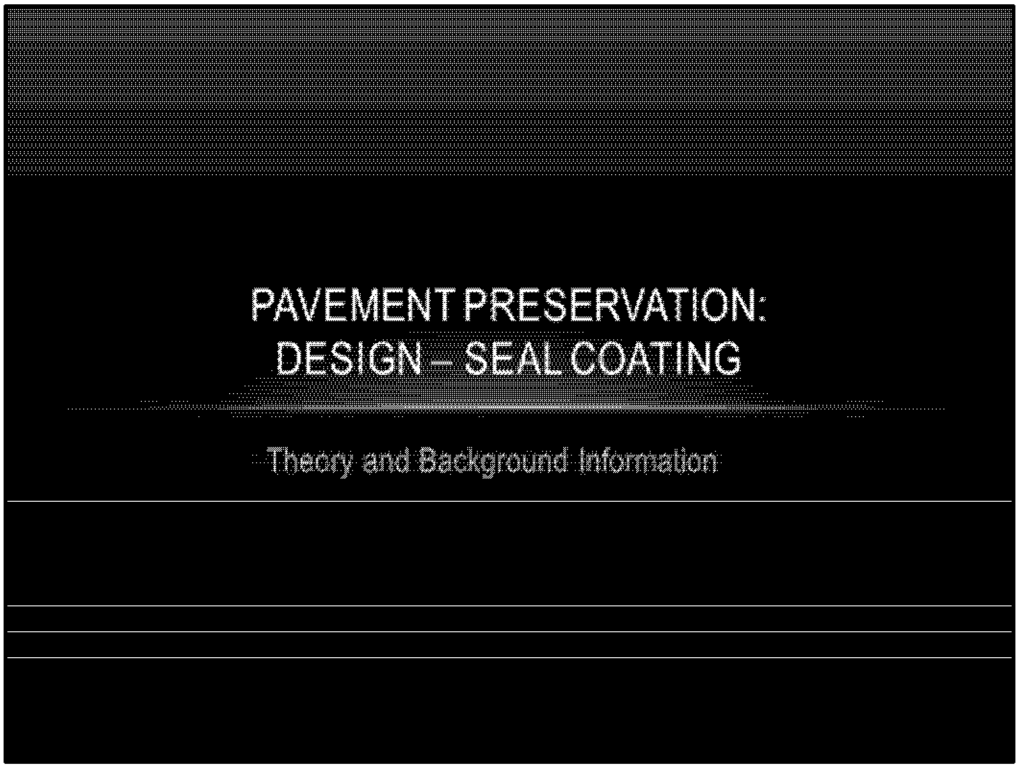


- Figuring out the correct time is the most difficult part of preventive maintenance.
- Right time (preventive vs. Corrective)
    - Treatments done in the corrective or reconstruction phase are more of holding strategies

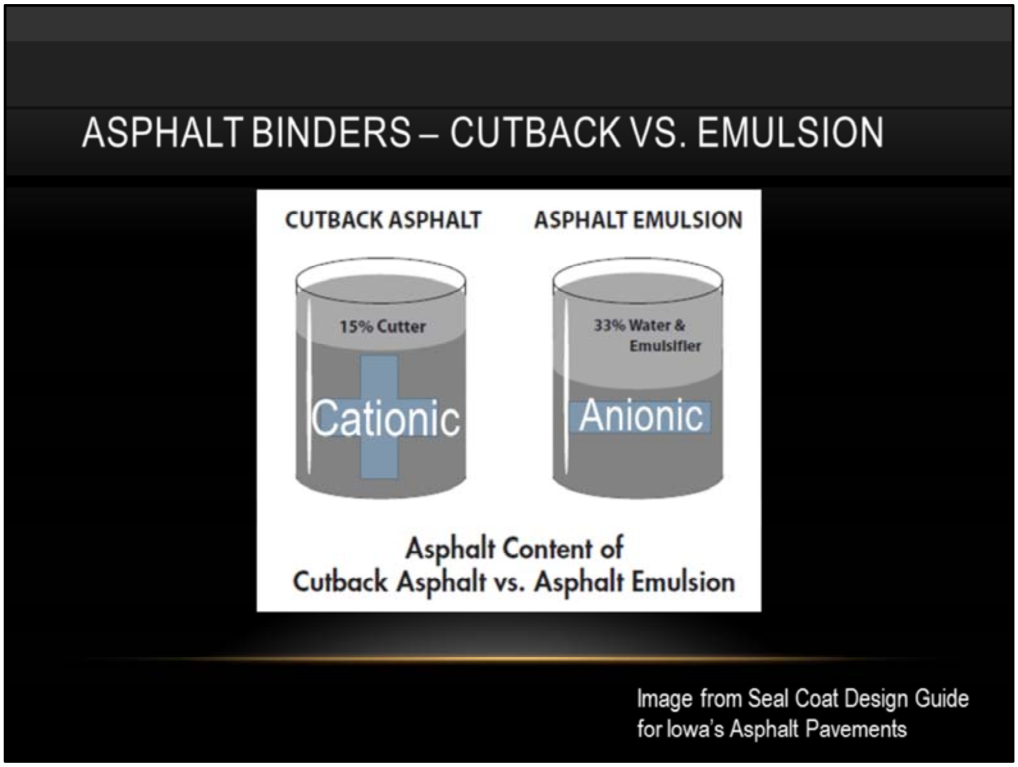
- One of the benefits of having a good asset management program is that it allows you to forecast the application of various treatments and give continuity to road maintenance.

SUMMARY

- The module has presented the major distresses typically found in road systems.
- To address such distresses, various treatments are available some performing better than others depending on road conditions.
- To help on the road and treatment selection process, various tools are available:
  - Asset management
  - Windshield Survey
  - Life Cycle Cost Analysis
  - Decision Matrices
- A combination of tools to help on the selection process is recommended.


PAVEMENT PRESERVATION:
DESIGN – SEAL COATING
Theory and Background Information


IMPORTANCE OF DESIGN TRAINING
This training module should:
Provide you with information on aggregate and binder considerations for seal coat designs.
Provide visual images and animations to help complement the information provided.
Examples of specs variations or possible additions.
Help you understand terms used on the design method provided by NHI and the Minnesota Seal Coat Handbook.
Proper selection and application of seal coats HAS to go hand-on-hand with a proper design to achieve expected benefits.



Cutback – asphalt cement dissolved in a solvent, typically kerosene or gasoline. Rapid curing cutbacks use gasoline while medium curing ones use kerosene. The amount of cutter affects the viscosity, thus more cutter less viscous or more fluid. The use of cutbacks has declined due to environmental and health risks.

Emulsions – consist of asphalt particles dispersed in water and chemically stabilized and suspended by emulsifiers. Emulsions are classified by their electrical charge, (+) cationic and (-) anionic, settling speed, high-float availability and viscosity.

Cationic vs. anionic – cationic is used more often since aggregates used for seal coats are usually negatively charged. Cationics are less sensitive to weather, stabilize quicker. Anionics are less critical when handling, need no close attention when storing.

High-float contains chemicals that allow for a thicker asphalt layer and could be used with dusty aggregates.

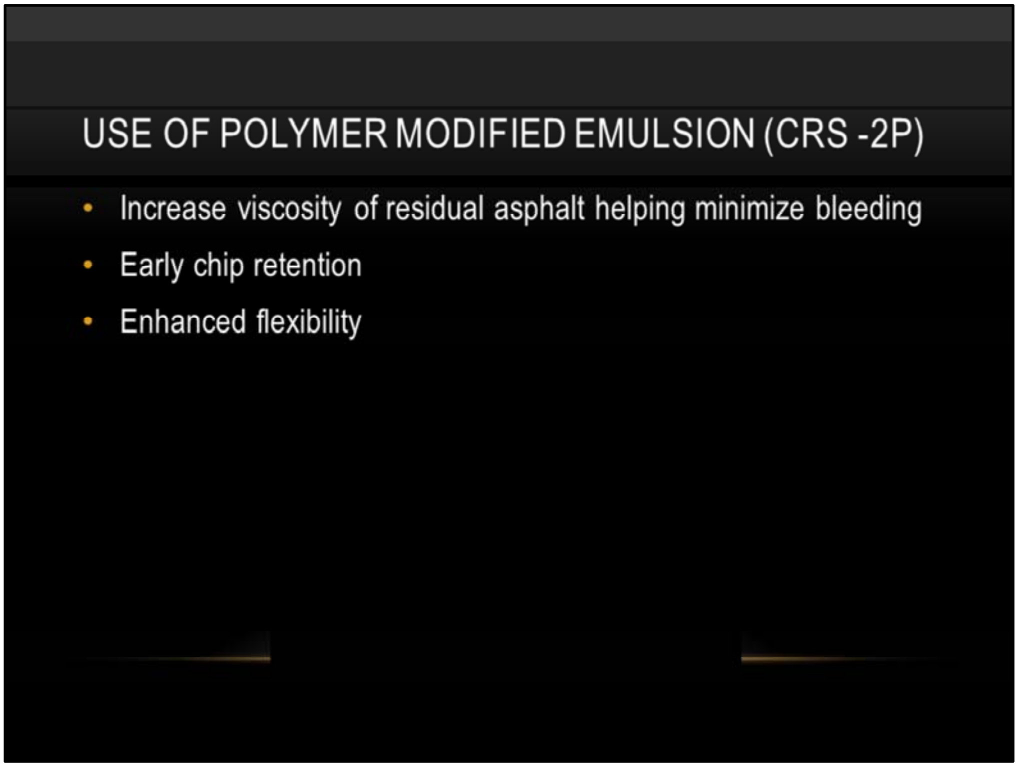
Viscosity for emulsions is designated by numbers 1 and 2, 1 is lower viscosity thus more fluid.

EMULSIONS (COMMONLY USED CRS-2)

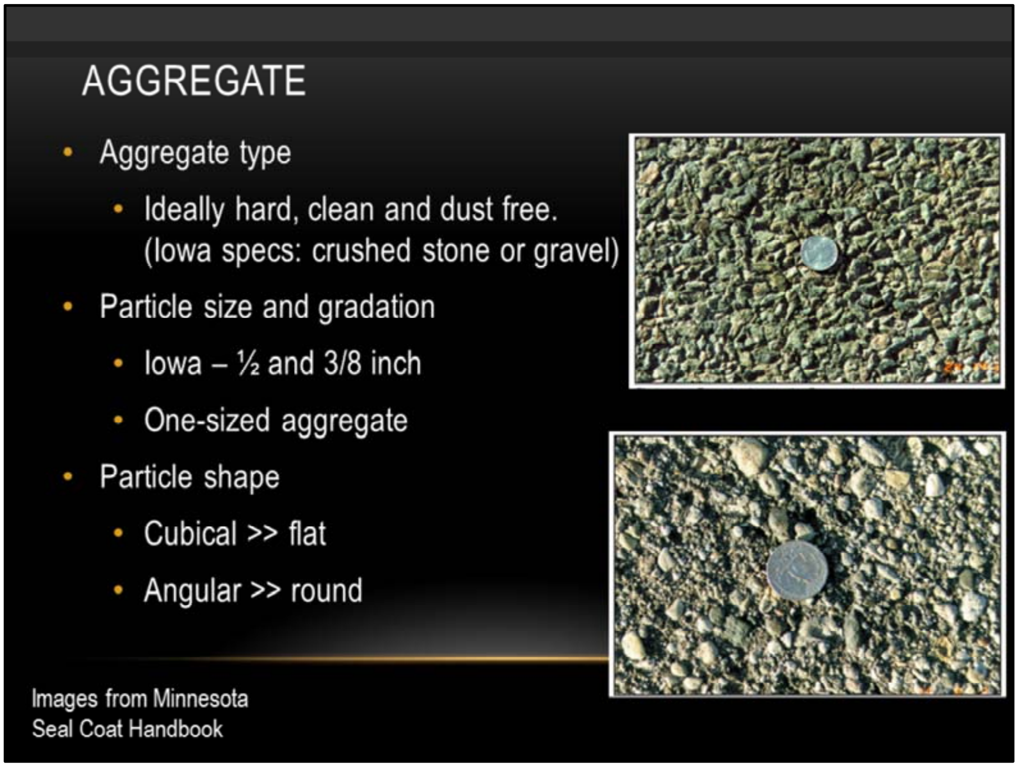
RS – Rapid Setting

MS – Medium Setting

SS – Slow Setting



Example CRS-2P



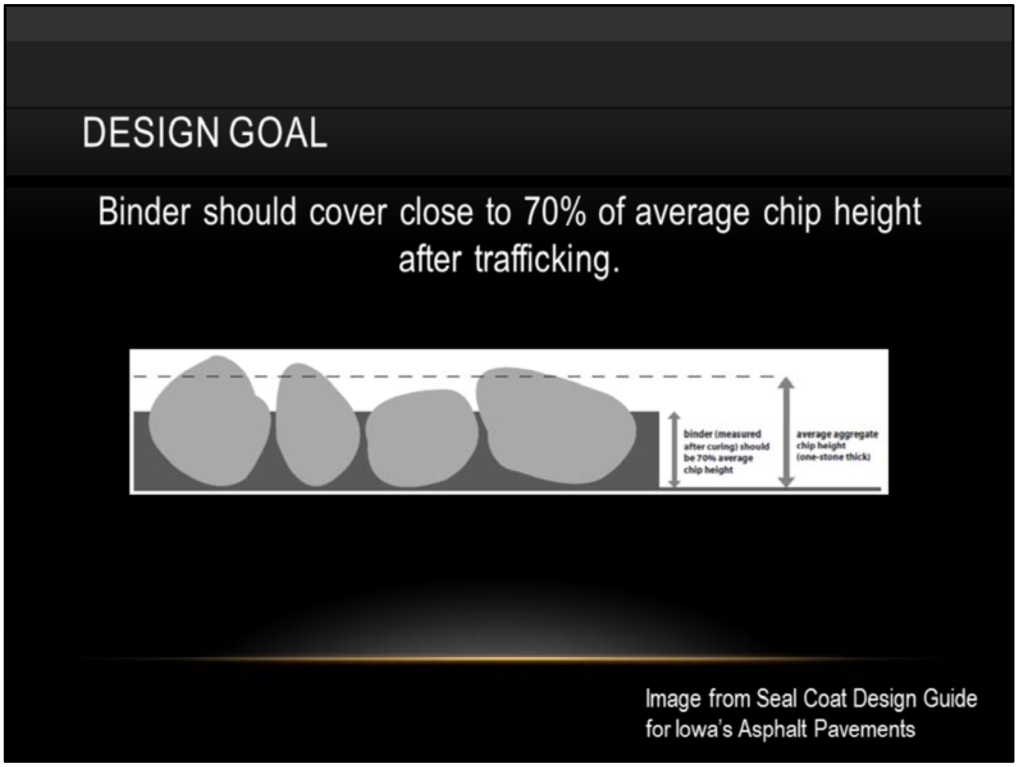
Clean – we wouldn't want other material, like organic material, mixed with the aggregates that will later get between the aggregates and binder. Also we want to avoid an aggregate with clayey content since clay will keep the binder from adhering to the aggregate.

One-sized aggregate for a single coat so that we achieve a uniform surface and no loose aggregate is settled on top of other aggregates.

Having a distributed gradation will not only cause chips to be placed over other chips without emulsion, but will also cause smaller chips to occupy the emulsion's space causing flushing.

Flat aggregates tend to lay on their flat side when traffic passes over it, think of it as a football

Angular aggregates help particles lock better between themselves, provide more surface adherence and are less susceptible to rolling and displacement.



50% before trafficking.

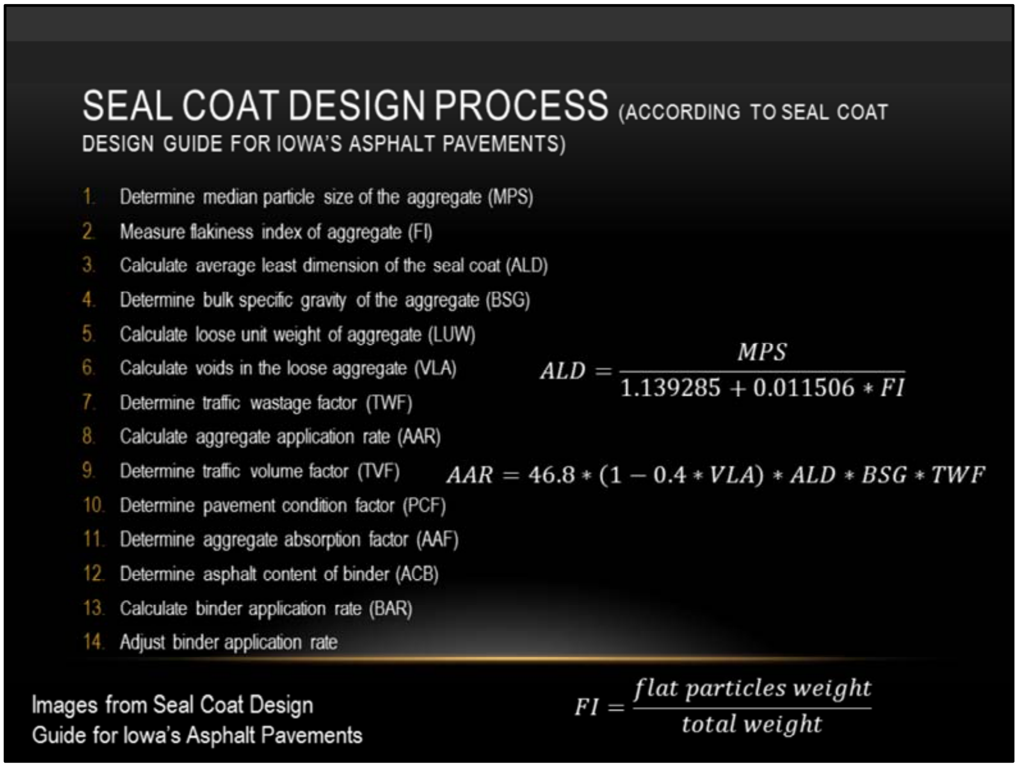
IOWA DOT SPECS RECOMMENDATIONS

Aggregate Size	Spreading Rate Gal. /Sq. Yds. (L/m²)	Basic Rate* Gal. /Sq. Yds. (L/m²)
Sand	0.15 - 0.20 (0.7 -0.9)	0.15 (0.8)
3/8 inch (9.5 mm)	0.25 - 0.35 (1.1 - 1.6)	0.30 (1.4)
1/2 inch (12.5 mm)	0.35 - 0.45 (1.6 - 2.0)	0.40 (1.8)
* The basic rate will be used for design purposes.		

Unless specified by the engineer:

- One Course:
  - Emulsion at 0.35 gal/yd²
  - Aggregate at 30 lb/yd²
- Two Course:
  - First layer same as One Course
  - Second layer of emulsion at 0.30 gal/yd²
  - Second layer of aggregate at 25 lb/yd²

Table from Iowa DOT Specification 2307



This presentation will not go through all calculations needed for designing seal coats, it will just go over the theory behind it. It shows a high-tech calculation process fairly acceptable for estimating quantities. For a design example with calculations please refer to video Seal Coat Design Example.

1. We determine the gradation (particle size distribution) using the sieve test and then we plot % vs. Opening size to determine the median particle size which will be the one corresponding to 50% passing.
2. Flakiness is the measure of the percent, by weight, of flat particles. A small sample is taken as chips that fit through the slots are considered to be flat. Lower FI = higher % of cubical aggregate.
3. ALD is a reduction of the MPS as it accounts for flakiness. ALD represents the seal coat thickness in the wheel path.
4. The lower the specific gravity, the lighter the aggregate is so less pounds of aggregate will cover a specific area. The bulk specific Gravity is determined using the AASHTO T 84 test.
5. LUW is needed to calculate the air voids expected between the aggregates, what will later become the space for the binder. Determined using the ASTM C29 test where 3 buckets of known volume and weight are filled with aggregate and the final weight is averaged.
6. VLA is a percentage in decimal expressing the volume of the seal coat occupied by voids. It commonly goes from 50% when placed to 30% when rolled and finally 20% when traffic has passed over it.

7. Traffic waste factor addresses the aggregate that gets whipped off to the side of the road due to traffic on a fresh seal. 5% is commonly used for low-volume residential areas and 10% for higher-speed roads.
8. It is a good practice to check your AAR by spreading the amount of aggregate in a one square yard box and seeing if the layer is one-stone thick.
9. The higher the traffic volume the lower the binder application rate, this happens because with higher volume of traffic more aggregates are forced onto their flat side so less binder is needed to cover 70% embedment.
10. Newer smoother roads with less voids require less binder and the other way around.
11. Aggregates absorb some of the binder applied therefore the binder needs to be corrected for this factor. This factor can be computed using the AASHTO T84 test. As a general rule if the absorption is 1.5% or higher an AAF of 0.02gal/yd2 is recommended, if less than 1.5% then these aggregates do not need correction.
12. ACB depends on the binder to be used expresses as a percentage on decimal.
13. This will determine how many gal/yd2 will be needed for the seal coat.
14. This rate may need adjustments due to the fact that roads are not perfect and thus some areas may need less or more binder along the road.

The smaller the circle of sand spread is, the more binder will be needed. Sand fills the voids of the pavements, thus providing a good interpretation of the surface macrotexture.

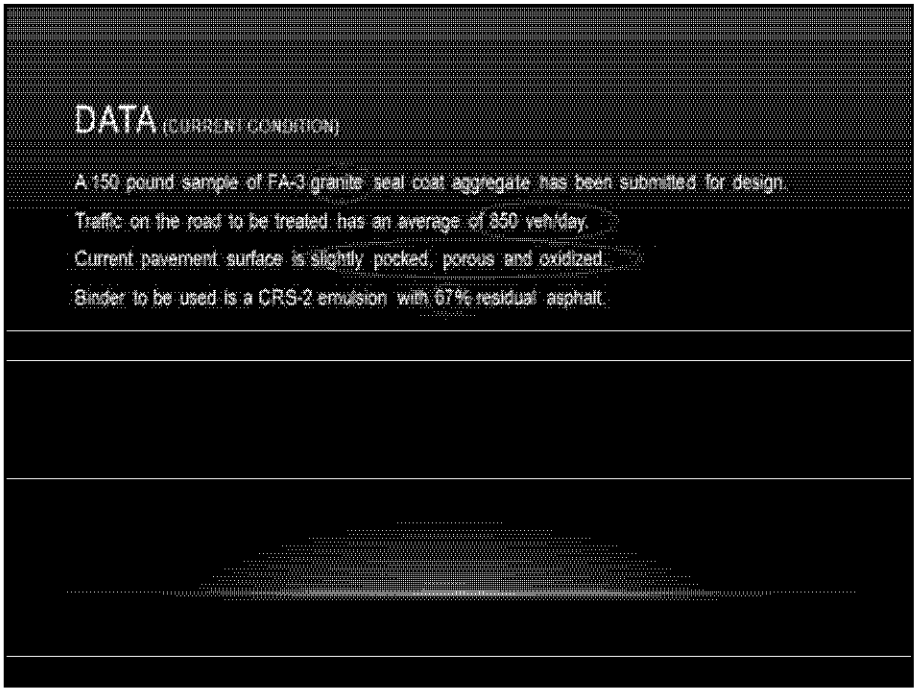
SUMMARY

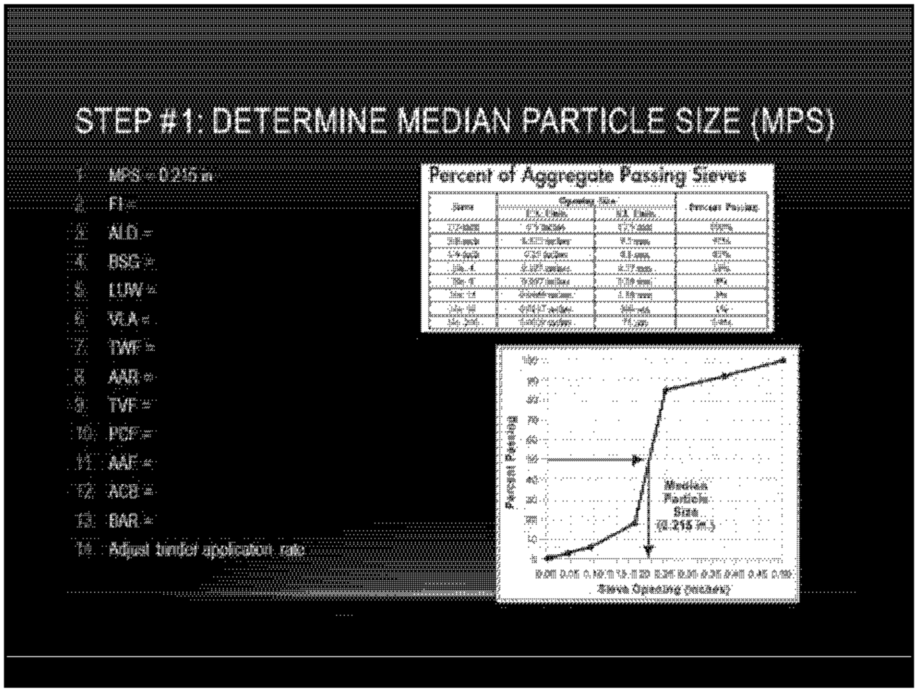
- Careful selection of both binder and aggregate are essential to a proper seal coat design as their properties, availability and cost will determine what to use.
- The design should always be checked in the field before application. It is common to find the aggregate application rate to be accurate and the binder application rate to need minor adjustments due to the fact that assumptions are made through the design process.
- Proper selection and application of seal coats HAS to go hand-on-hand with a proper design to achieve expected benefits.

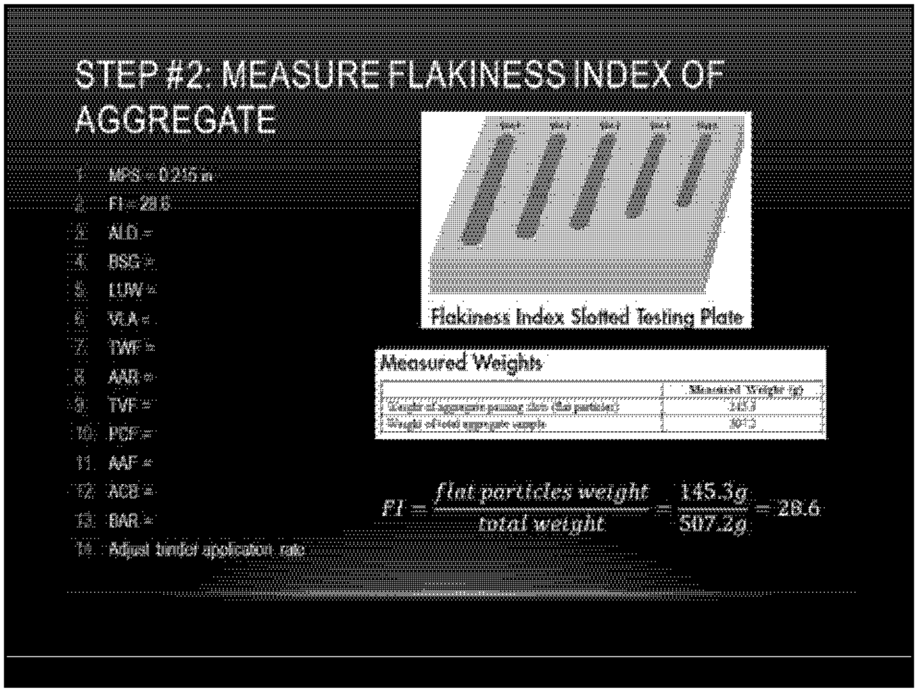
PAVEMENT PRESERVATION: DESIGN – SEAL COAT EXAMPLE

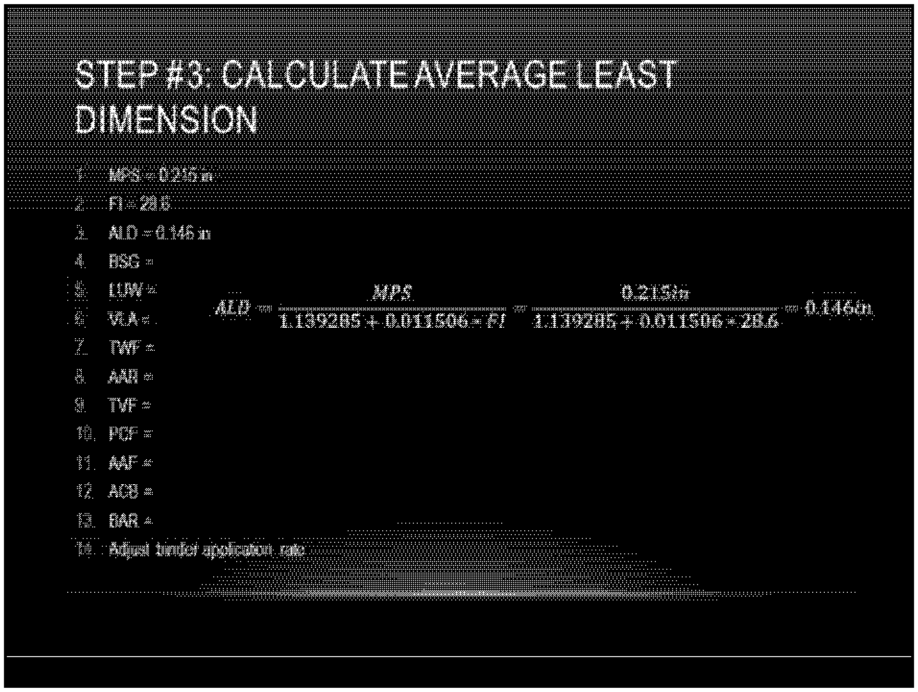
(follows the same example found on the Seal Coat Design Guide for Iowa's Asphalt Pavement – adapted from Minnesota Seal Coat Handbook)

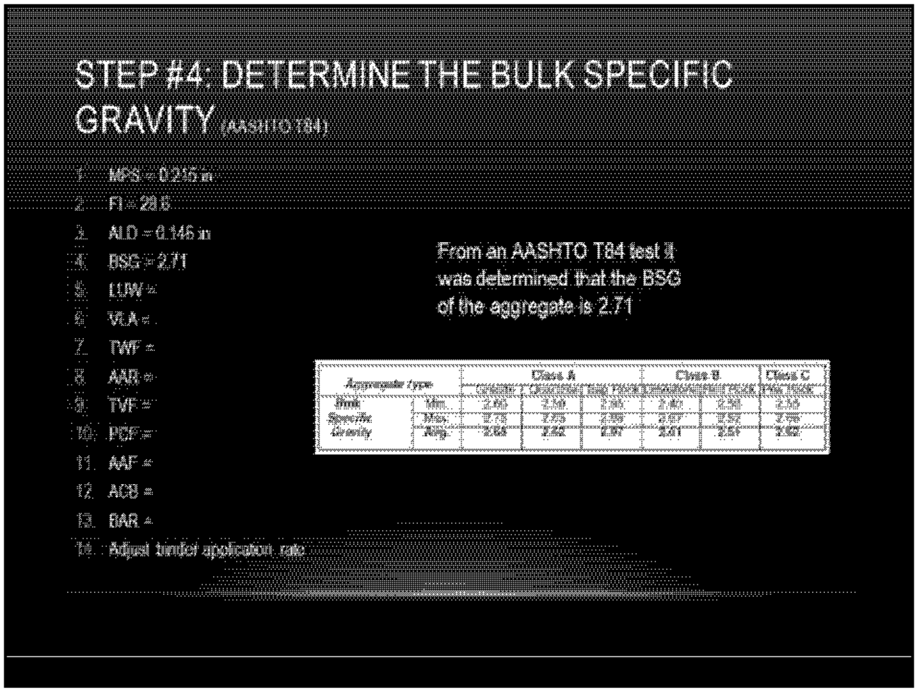

STEPS TO FOLLOW (CAN BE CHANGED)
1. Determine median particle size of the aggregate (MPS)
2. Measure flakiness index of aggregate (FI)
3. Calculate average least dimension of the seal coat (ALD)
4. Determine bulk specific gravity of the aggregate (BSG)
5. Calculate loose unit weight of aggregate (LUW)
6. Calculate voids in the loose aggregate (VLA)
7. Determine traffic wastage factor (TWF)
8. Calculate aggregate application rate (AAR)
9. Determine traffic volume factor (TVF)
10. Determine pavement condition factor (PCF)
11. Determine aggregate absorption factor (AAF)
12. Determine asphalt content of binder (ACB)
13. Calculate binder application rate (BAR)
14. Adjust binder application rate

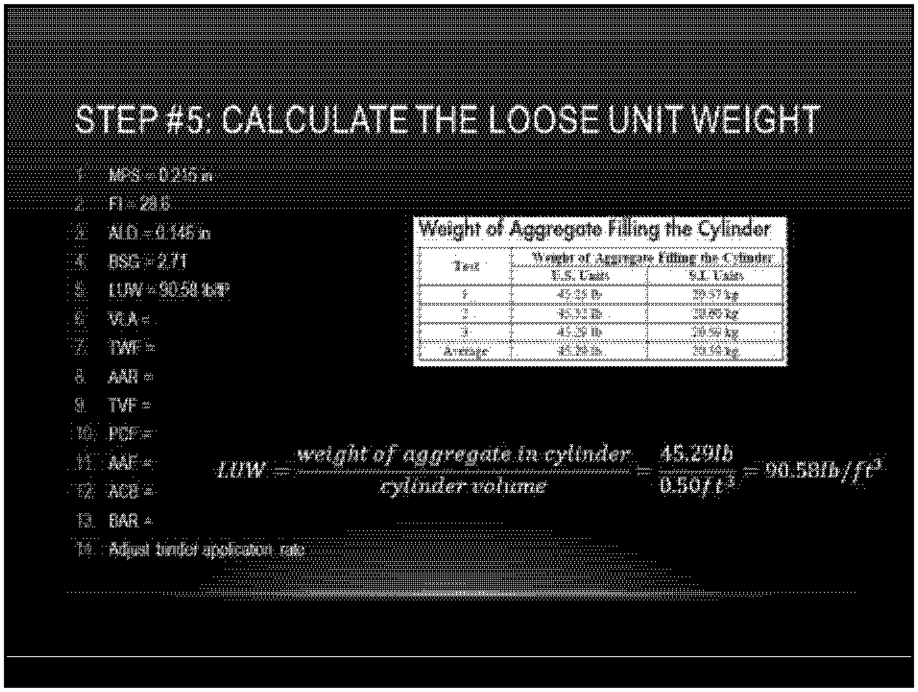

DATA (CURRENT CONDITION)
A 150 pound sample of FA-3 granite seal coat aggregate has been submitted for design.
Traffic on the road to be treated has an average of 850 veh/day.
Current pavement surface is slightly pocked, porous and oxidized.
Binder to be used is a CRS-2 emulsion with 67% residual asphalt.


STEP #1: DETERMINE MEDIAN PARTICLE SIZE (MPS)
1. MPS = 0.215 in
2. FI =
3. ALD =
4. BSG =
5. LUW =
6. VLA =
7. TWF =
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
Percent of Aggregate Passing Sieves
Percent Passing
Median Particle Size (0.215 in.)
Sieve Opening (inches)


STEP #2: MEASURE FLAKINESS INDEX OF AGGREGATE
1. MPS = 0.215 in
2. FI = 28.6
3. ALD =
4. BSG =
5. LUW =
6. VLA =
7. TWF =
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
Flakiness Index Slotted Testing Plate
Measured Weights
$FI = \frac{flat\ particles\ weight}{total\ weight} = \frac{145.3g}{507.2g} = 28.6$


STEP #3: CALCULATE AVERAGE LEAST DIMENSION
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.146 in
4. BSG =
5. LUW =
6. VLA =
7. TWF =
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
$$ALD = \frac{MPS}{1.139285 + 0.011506 * FI} = \frac{0.215in}{1.139285 + 0.011506 * 28.6} = 0.146in$$


STEP #4: DETERMINE THE BULK SPECIFIC GRAVITY (AASHTO T84)
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.146 in
4. BSG = 2.71
5. LUW =
6. VLA =
7. TWF =
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
From an AASHTO T84 test it was determined that the BSG of the aggregate is 2.71
Aggregate type
Class A
Class B
Class C


STEP #5: CALCULATE THE LOOSE UNIT WEIGHT
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.145 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA =
7. TWF =
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
Weight of Aggregate Filling the Cylinder
Test
U.S. Units
S.I. Units
Average
LUW = weight of aggregate in cylinder / cylinder volume = 45.29lb / 0.50ft³ = 90.58lb/ft³

STEP #6: CALCULATE VOIDS IN THE LOOSE AGGREGATE

1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.146 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA = 0.46
7. TWF =
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate

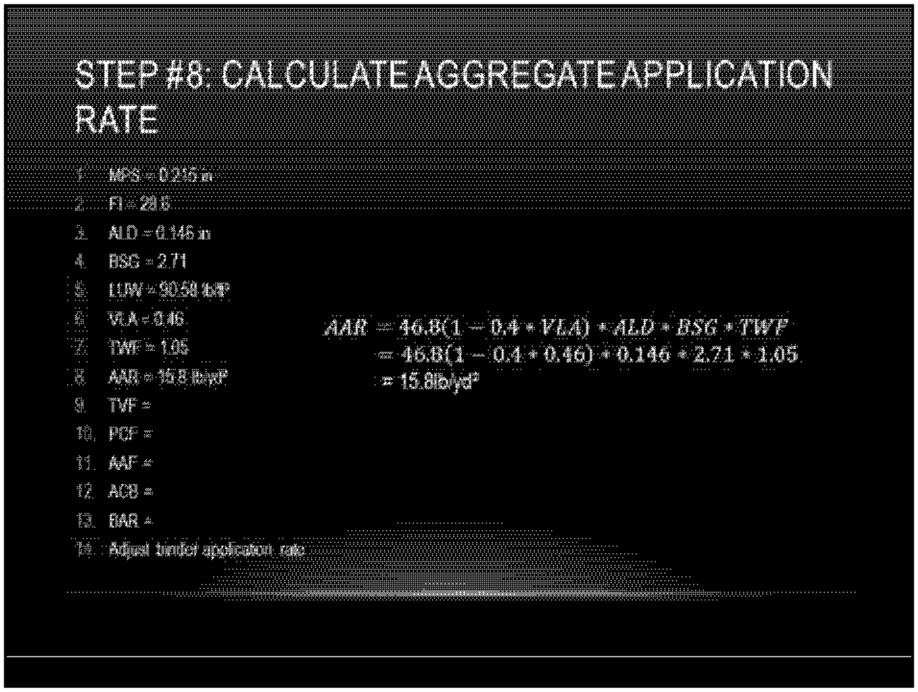
$$VLA = 1 - \frac{LUW}{62.4 * BSG} = 1 - \frac{90.58}{62.4 * 2.71} = 0.46$$

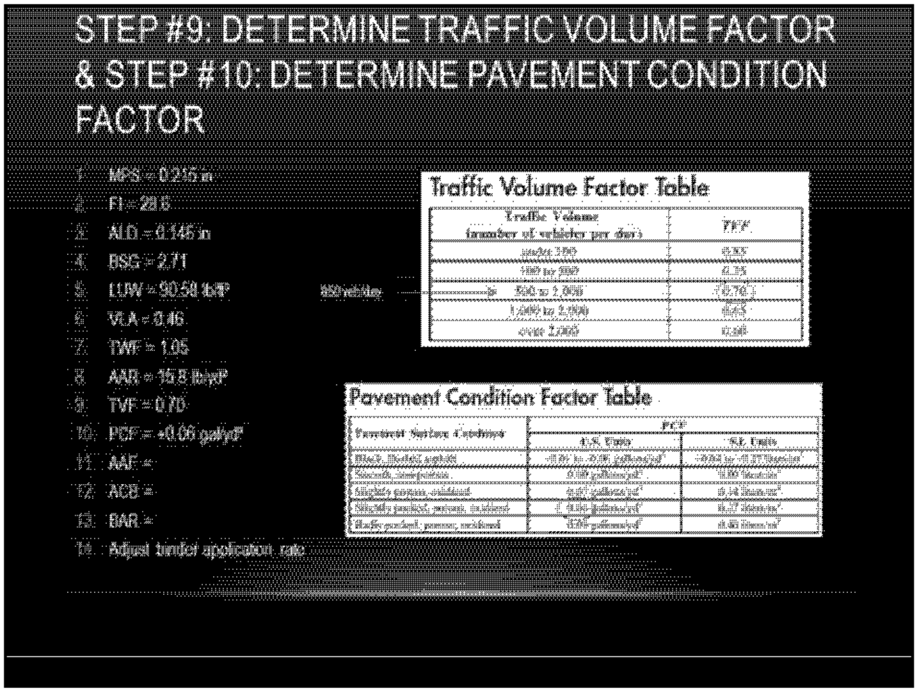
STEP #7: DETERMINE TRAFFIC WASTE FACTOR

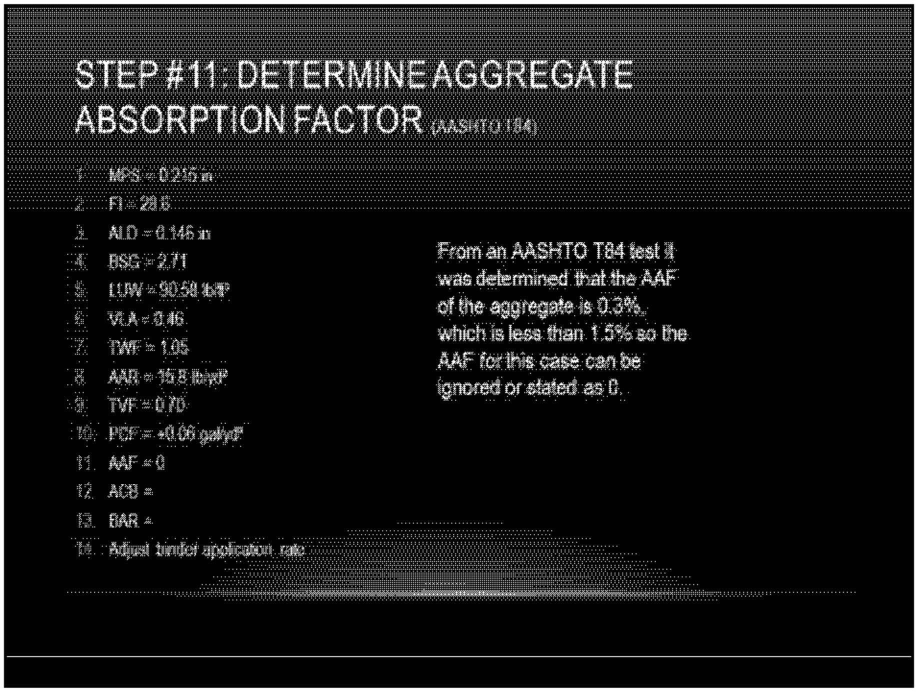
1. MPS = 0.215 in
2. FI = 28.8
3. ALD = 0.145 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA = 0.46
7. TWF = 1.05
8. AAR =
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate

Percent Waste Allowed and Traffic Wastage Factor

Percent Waste Allowed	TWF
1%	1.01
2%	1.02
3%	1.03
4%	1.04
5%	1.05
6%	1.06
7%	1.07
8%	1.08
9%	1.09
10%	1.10
11%	1.11
12%	1.12
13%	1.13
14%	1.14
15%	1.15

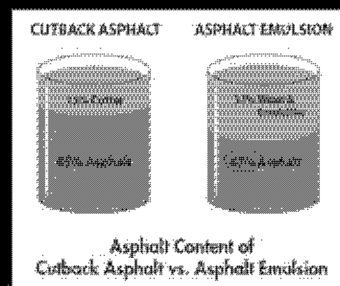

STEP #8: CALCULATE AGGREGATE APPLICATION RATE
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.146 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA = 0.46
7. TWF = 1.05
8. AAR = 15.8 lb/yd²
9. TVF =
10. PCF =
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
$AAR = 46.8(1 - 0.4 * VLA) * ALD * BSG * TWF$
$= 46.8(1 - 0.4 * 0.46) * 0.146 * 2.71 * 1.05$
$= 15.8 lb/yd^2$

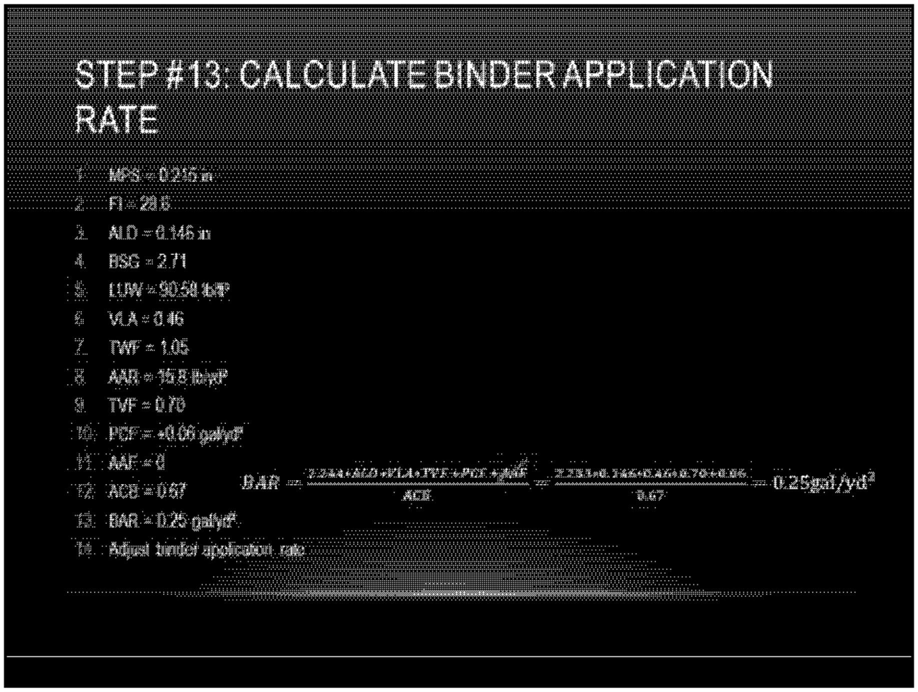

STEP #9: DETERMINE TRAFFIC VOLUME FACTOR & STEP #10: DETERMINE PAVEMENT CONDITION FACTOR
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.145 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft^3
6. VLA = 0.46
7. TWF = 1.05
8. AAR = 15.8 lb/yd^2
9. TVF = 0.70
10. PCF = +0.06 gal/yd^2
11. AAF =
12. ACB =
13. BAR =
14. Adjust binder application rate
Traffic Volume Factor Table
Pavement Condition Factor Table


STEP #11: DETERMINE AGGREGATE ABSORPTION FACTOR (AASHTO T84)
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.146 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA = 0.46
7. TWF = 1.05
8. AAR = 15.8 lb/yd²
9. TVF = 0.70
10. PCF = +0.06 gal/yd²
11. AAF = 0
12. ACB =
13. BAR =
14. Adjust binder application rate
From an AASHTO T84 test it was determined that the AAF of the aggregate is 0.3%, which is less than 1.5% so the AAF for this case can be ignored or stated as 0.

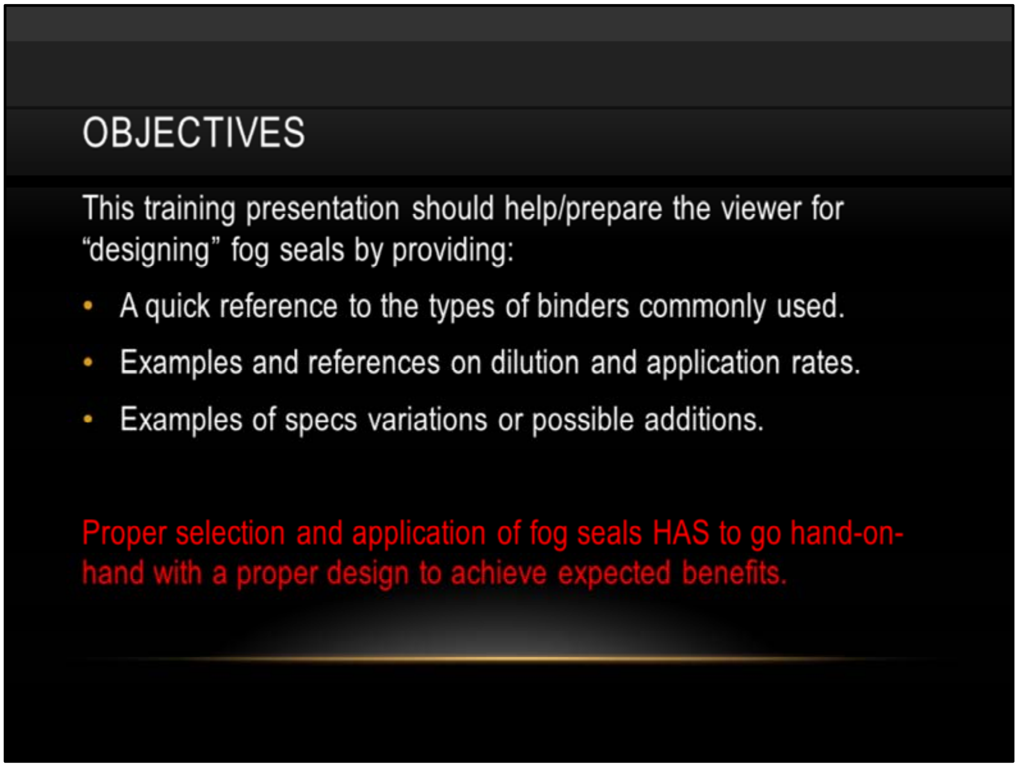
STEP #12: DETERMINE ASPHALT CONTENT ON BINDER

1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.145 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA = 0.46
7. TWF = 1.05
8. AAR = 15.8 lb/yd²
9. TVF = 0.70
10. PCF = +0.06 gal/yd²
11. AAF = 0
12. ACB = 0.67
13. BAR =
14. Adjust binder application rate

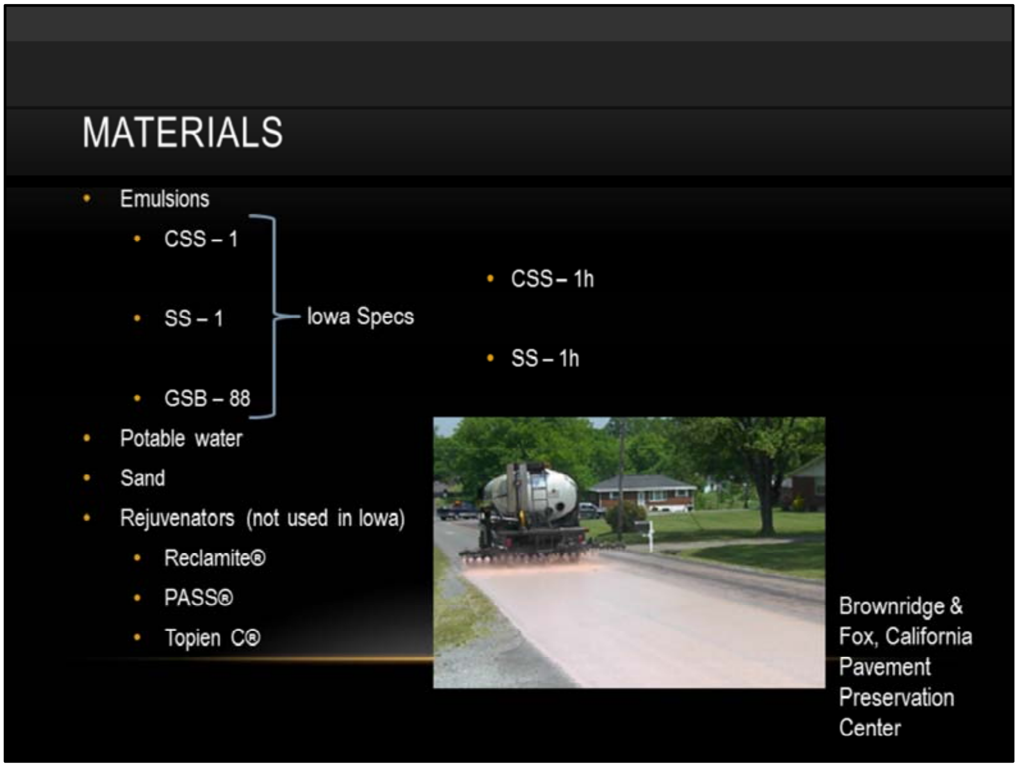



STEP #13: CALCULATE BINDER APPLICATION RATE
1. MPS = 0.215 in
2. FI = 28.6
3. ALD = 0.146 in
4. BSG = 2.71
5. LUW = 90.58 lb/ft³
6. VLA = 0.46
7. TWF = 1.05
8. AAR = 15.8 lb/yd²
9. TVF = 0.70
10. PCF = +0.06 gal/yd²
11. AAF = 0
12. ACB = 0.67
13. BAR = 0.25 gal/yd²
14. Adjust binder application rate
$BAR = \frac{2.244 \cdot ALD \cdot VLA \cdot TVF + PCF + AAF}{ACB} = \frac{2.244 \cdot 0.146 \cdot 0.46 \cdot 0.70 + 0.06}{0.67} = 0.25 gal/yd^2$


PAVEMENT PRESERVATION:
DESIGN – FOG SEALS



I have "designing" within "" (quotations mark) because, when compared to seal coating for example, there is not really a design behind a fog seal. Dilution and application rates have already been established and the DOT specs state what to use. Nonetheless a proper selection needs to be made and verified.



Emulsions:
- CSS – cationic emulsion, positively charged
- SS – anionic, negatively charged, they tend to take longer to stabilize than css
- Gsb – natural asphalt ore with high resin content (gilsonite – found in Utah mines and Saudi Arabia), combined with oils and plasticizers creating a cationic emulsion. GSB advantage is that it significantly retards deterioration when compared to conventional fog seals but its initial cost is higher.
- Css – 1h and ss – 1h are not in the Iowa specs, but states like California commonly use them to create a thicker layer.

Water – needs to be potable to minimize the risk of adding pollutant or contaminants to the diluted emulsion that would alter the chemical composition.

Sand – a sand cover usually follows a fog seal to compensate for the loss of road friction that occurs from a fresh fog seal. (required in Iowa)

Rejuvenators – oily additives that soften the binder, reduce their viscosity, thus providing deeper surface penetration to restore AC components and characteristics.
- Reclamite – oil based emulsion with a surfactant
- Pass – polymer modified asphalt surface sealer
- Topien – oil based asphalt with chemical additives

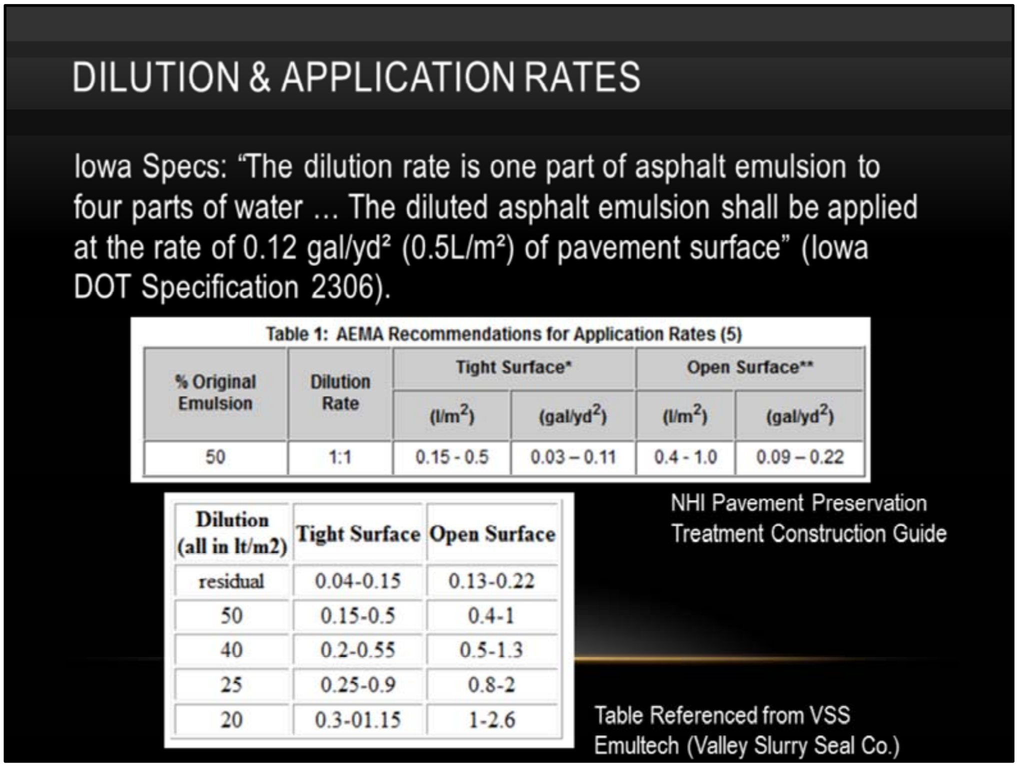


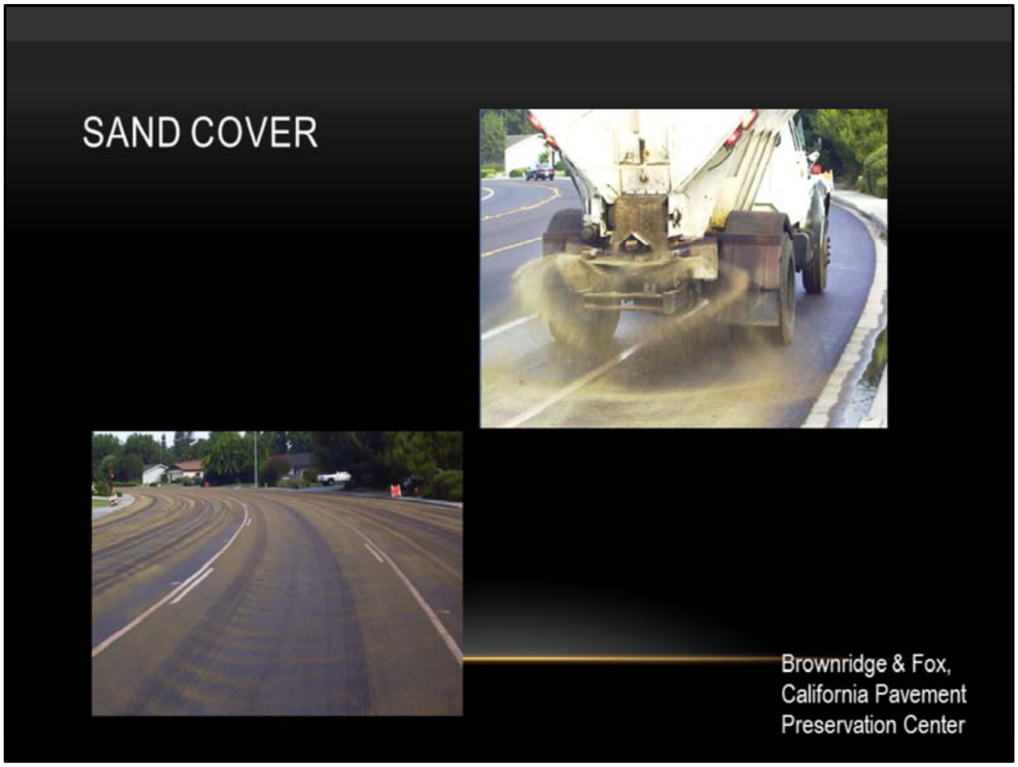
Table 1: AEMA Recommendations for Application Rates (5)

% Original Emulsion	Dilution Rate	Tight Surface*		Open Surface**	
		(l/m^2)	(gal/yd^2)	(l/m^2)	(gal/yd^2)
50	1:1	0.15 - 0.5	0.03 – 0.11	0.4 - 1.0	0.09 – 0.22

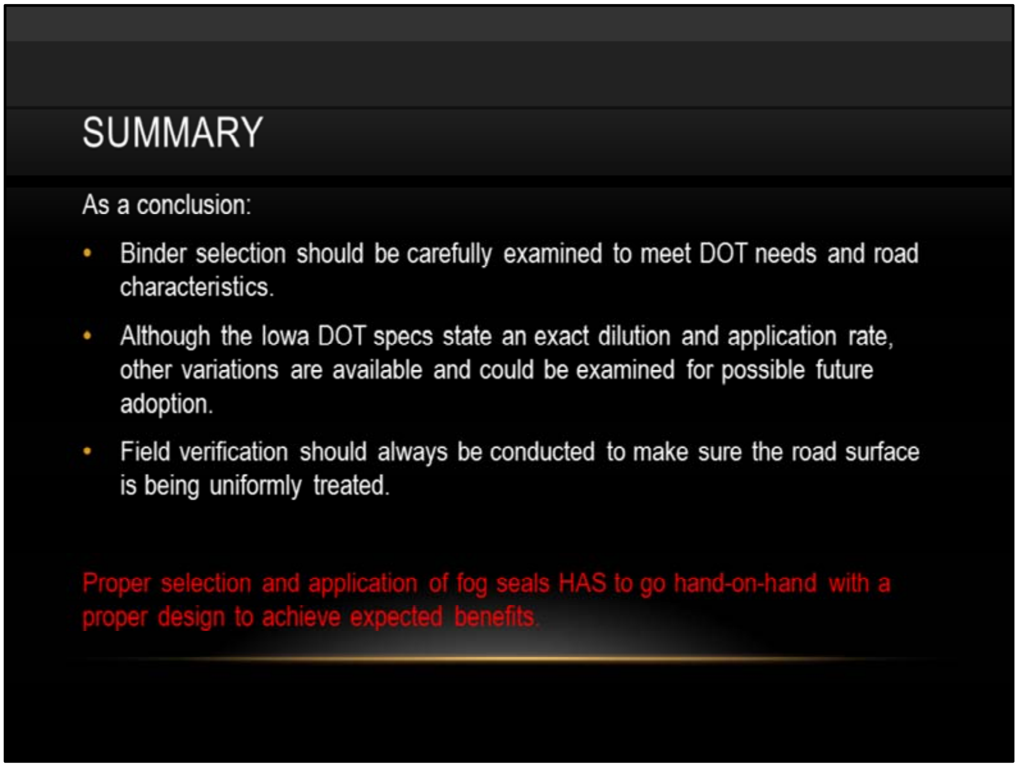
Dilution (all in lt/m2)	Tight Surface	Open Surface
residual	0.04-0.15	0.13-0.22
50	0.15-0.5	0.4-1
40	0.2-0.55	0.5-1.3
25	0.25-0.9	0.8-2
20	0.3-01.15	1-2.6

Although the recommended dilution rate nationwide is a 1:1 dilution rate, here in Iowa a dilution rate of 1:4 is used.

Note that the dilution and, specially, the application rates need to be checked and adjusted in the field to compensate for the actual environmental and road conditions.

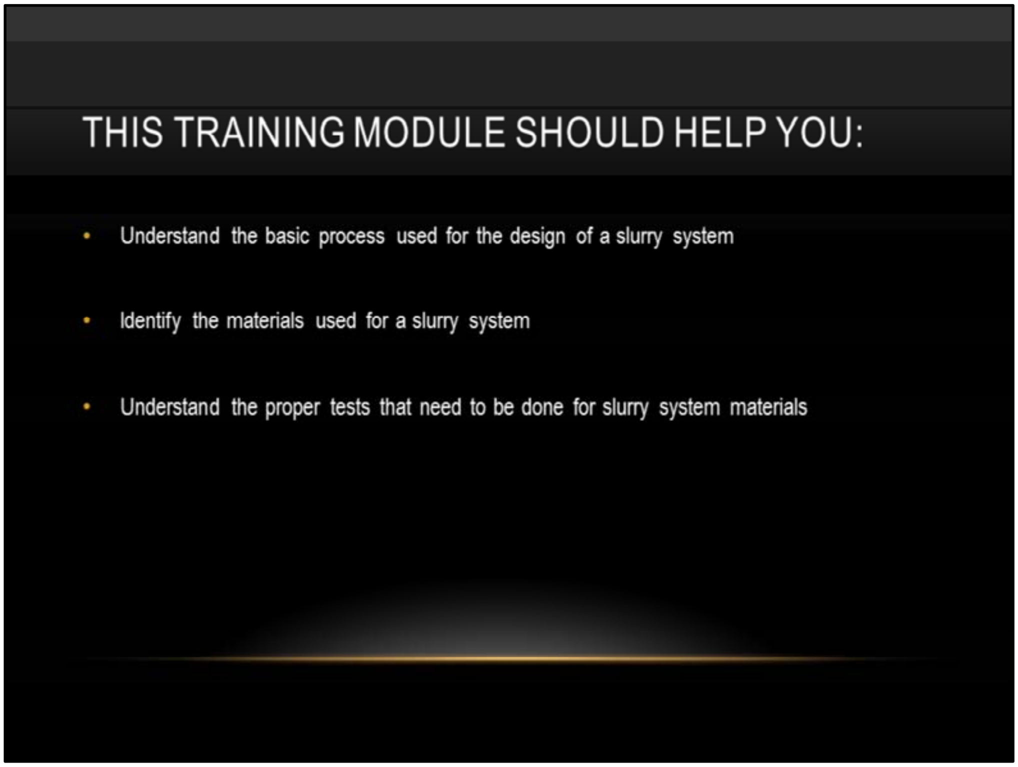


As mentioned before, a sand cover usually follows a fog seal to compensate for the loss of road friction that occurs from a fresh fog seal.



Know the difference between a CSS, SS and GSB and what the DOT objectives for a specific road are. Although GSB is more expensive, it may be the proper choice according to what the DOT expects.

Designs will be performed through the contractor by and outside laboratory and the Iowa DOT will only need to review and approve designs.



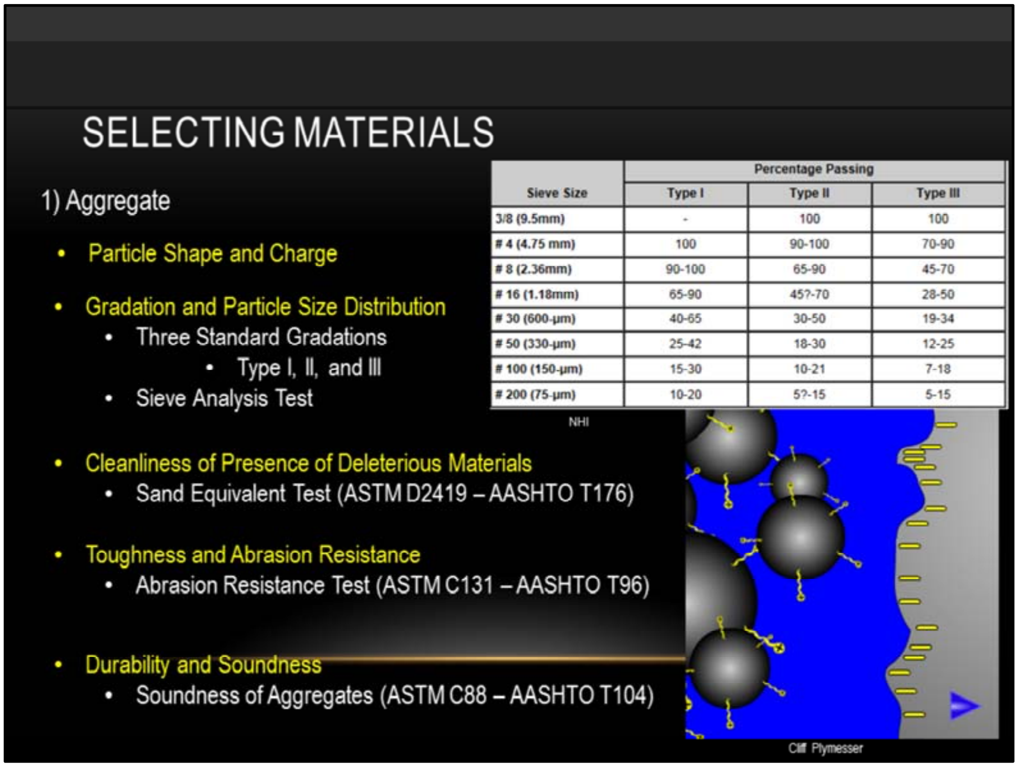
It is important to as a designer to understand this process so that you can be quality control and make sure things are done correctly.

- DOT Selects aggregate gradation
- Contractor selects aggregate source/type
- Contractor sends aggregate off to a laboratory
- Ship aggregate to emulsifier
    - Tells what emulsion needs to be used for the aggregate
- The lab will make up their own mixtures according to specifications, but the %'s are developed by other entities

RESPONSIBILITIES

Iowa DOT	Contractor	Emulsion Supplier
Specifies aggregate gradation	Chooses aggregate source	Develops the *job mix formula*
Specifies emulsion types and tests.	Completes the final mixture and applies the treatment	Performs all required laboratory tests
Specifies the mineral fillers and additives that can be used		
Specifies application rates		
Determines number of lifts and type of treatment application		

It is important to briefly review the responsibilities of each member of the design process. This table shows that there are three main entities involved in the design process: Iowa DOT, Contractor, and emulsion supplier. This table shows the main responsibilities of each entity.



<u>Aggregate</u>

1. Gradation and Particle Size Distribution:

- Aggregate from a single source may not change, but inspectors should be alert for the following
    - Change in aggregate production methods
    - Different phases of the project occurring over a long period of time
    - Changes within the quarry or pit where aggregates are extracted
    - Gradation fluctuation, because large variations can ruin a project
- Slurry seals are to be applied one stone thick. Forcing the slurry to be placed too thin or too thick will create and unstable seal.

- Type I: (Only Slurry Seal) Smallest size used for filling surface voids or cracks and to correct moderate surface conditions when protection from the elements is the main reason for resurfacing. 1/8" Top Size gradation (3-4 mm).
- Type II: Used to fill surface voids and correct moderate surface conditions. Used on pavements with medium-textured surfaces that would require the Type II size aggregate to correct weathering and reveling while producing an adequate wearing surface for medium to heavy traffic. ¼" Top Size Gradation (5-6 mm).
- Type III: Coarsest aggregate giving the maximum coefficient of friction. Best suited for higher-traffic pavements. 3/8" Top Size gradation (9-10 mm).

2. Particle Shape and Charge:

Shape:

- 100% Crushed aggregate should be used. The fractured faces allow the particles to seat and lock together to better resist movement
- Large round rock particles will ravel out of slurry system treatments
- Slurry system mixtures with a higher percentage of flat and elongated aggregates (3:1) have lower shear stiffness.
- Some aggregate could meet the project specification for crushed aggregate, but crushed elongated aggregate can cause drag marks in the surface

Charge:

- The crushed shape of an aggregate can play into its charge
- The efficiency with which an emulsion breaks is influenced b the charge characteristics of the aggregate
- Most aggregates are negatively charged with the exception of limestone
- Freshly crushed aggregate also has a higher surface charge than an aged aggregate
- When an aggregate is crushed to where it has many jagged edges makes the aggregate more negatively charged
- Clay is also very negatively charged and can be more attractive than the aggregate if the surface is dirty with it

3. Cleanliness and Presence of Deleterious Materials:

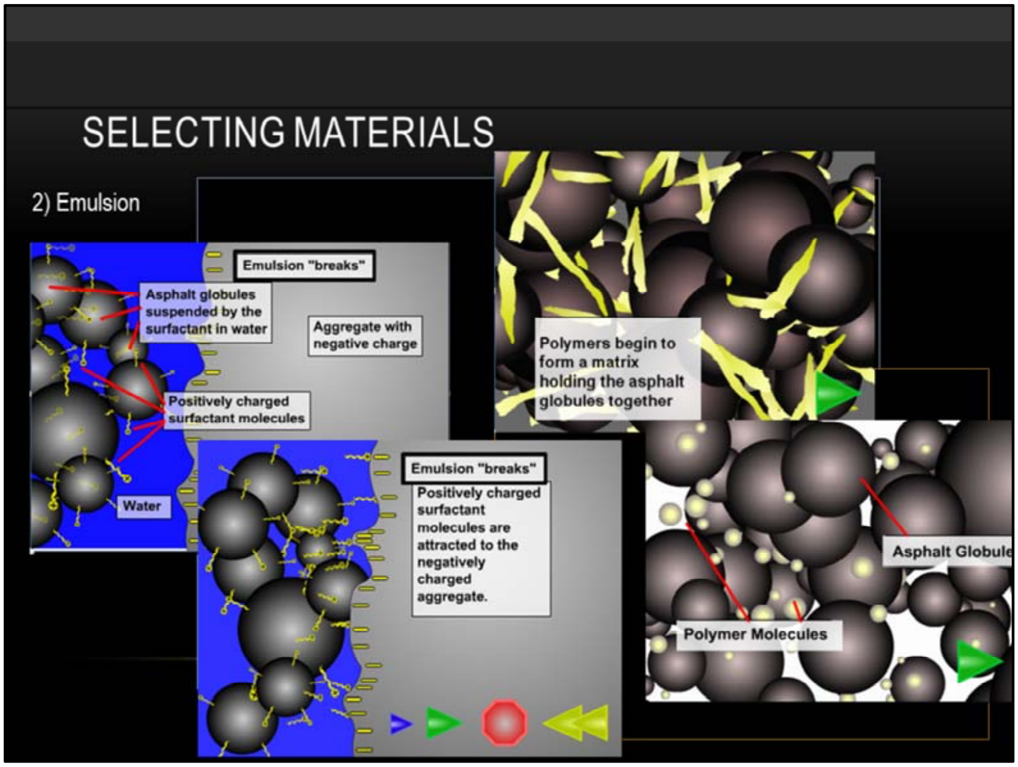
- Aggregates must be relatively clean when sued in slurry systems.
- Vegetation, soft particles, clay clumps, and excess dust are examples of uncleanliness
- Unclean aggregates will affect the general performance by quickly degrading the surface and/or preventing aggregate-binder bonding

4. Toughness and Abrasion Resistance:

- Aggregate go through wear and tear through their lives due to <u>normal production activity</u>
- Should be able to resist crushing, degradation, and disintegration
- If an aggregate is not resistant to abrasion or polishing it will cause a loss of skid resistance for the entire surface

5. Durability and Soundness

- Aggregates must be resistant to breakdown and disintegration from weathering such as wetting/drying and freezing/thawing



Emulsion

- An emulsion is a colloid of water, an emulsifier, and asphalt.
- Warm asphalt is milled into very small globules and dispersed into water via an emulsifier (surfactant).

* Surfactant: One end is hydrophobic and one end is hydrophilic.
* The emulsifier will define the overall charge of emulsion – if the surfactant is negatively charged it is anionic and if the surfactant is positively charged it is cationic.

Slurry seals will break through evaporation of water, but microsurfacing will break through a chemical reaction between the emulsion and the aggregate, forcing the water out.

- A microsurfacing emulsion will always be polymer modified.
- Emulsion specifications are based on standard emulsion characteristics, such as stability, binder content, and viscosity. In all microsurfacing systems, polymer is added to the emulsion. The polymer enhances stone retention, especially in the early life of the treatment. The added polymer also reduces thermal susceptibility. Polymers also improve softening point and flexibility, which enhance the treatment's crack resistance and, in the case of microsurfacing, allow thicker sections (two to three stones thick) to be placed. Thicker sections allow microsurfacing to be used for rut filling. Generally, microsurfacing is not significantly resistant to reflective cracking.

Microsurfacing

Test	Typical Specification	Method
Residue	62% min	AASHTO T 59
Sieve Content	0.3% max	AASHTO T 59
Viscosity 25°C SSF	15-90	AASHTO T 59
Stability (1 day)	1% max	ASTM D244
Storage Stability (5 days)	5% max	ASTM D244
Residue pen 25°C	40-90	ASTM D244

NHI

Slurry Seals

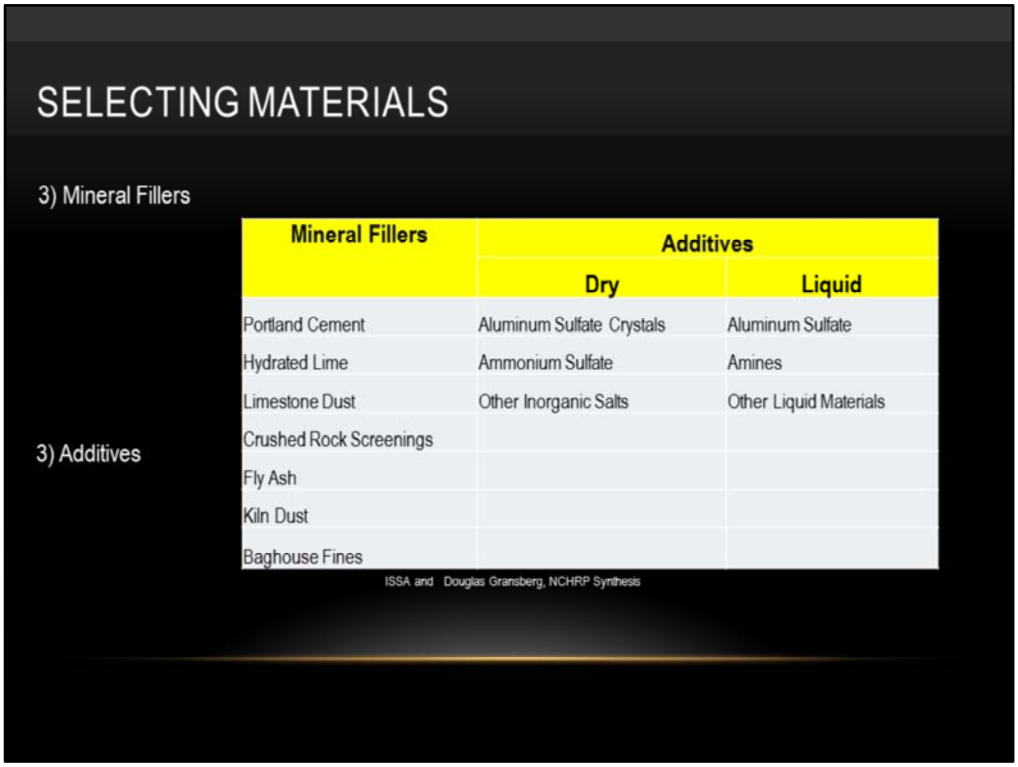
Test	Typical Specification	Method
Residue	62% min	AASHTO T 59
Sieve Content	0.3% max	AASHTO T 59
Viscosity @ 25°C, SSF	15-90	AASHTO T 59
Stability (1 day)	1% max	ASTM D244
Storage Stability (5 days)	5% max	ASTM D244
Residue pen @ 25°C	40-90	ASTM D244
R&B SP, °C	57 min	AASHTO T 53
Torsional Recovery	18% min (LMCQS-1h)	AASHTO T 59
Polymer Content	2.5% min (LMCQS-1h)	State Agency Test Method, such as : Caltrans CT 401

NHI

Emulsion tests –

- Residual Asphalt Content – Determines the amount of asphalt in the solution
- Penetration Test on Residue – Tests and defines the hardness of the asphalt
- Viscosity Test – Provides control of consistency in the range of temperatures associated with field operations
- Electrical Charge Test – Identifies anionic or cationic charge
- Sieve Test – Identifies oversized or coagulated particles
- Settlement Tests – Evaluates storage stability
- Ring and Ball Test – Identifies the point at which the asphalt softens

* All Tests shown are done by Emulsion manufacturer, but not all the tests are currently required in the Iowa DOT specification. The tests outlined in red are the tests required by the Iowa DOT specification.



<u>Mineral Fillers</u>

- Mixing aid allowing the mixing time to be extended and creating a creamy consistency that is easy to spread. When the mineral fillers react with the emulsion it results in a mix that break faster with a shorter curing time (NHI).
- Mineral fillers also promote cohesion and form a mortar with the residual asphalt

<u>Additives</u>

- Mineral fillers are an example of dry additives, but there are more dry and also liquid additives.
- Different concentrations of additives used throughout an application allow a contractor to control the breaking and curing times to correspond to the fluctuating temperatures throughout the day.

*The difference between mineral fillers and additives is that mineral fillers are always considered a dry additive but not all dry additives are considered mineral fillers as some will dissolve in water.

DEVELOPING A JOB MIX FORMULA & TESTING

1) Select Materials: emulsion, aggregate, mineral filler, additives, and water – COMPLETE

2) Develop a job mix formula (Laboratory Testing of Materials)
   - Mixing Proportions
   - Abrasion Resistance
   - Upper Binder Limit
   - Optimum Binder
3) Final Testing

4) Identify Application Rates

Mixing Proportions

The development of a job mix formula fundamentally involves calculating the proportions of each component to the slurry system mix.

ISSA A143 (2010b) is used as the guideline for microsurfacing from which the job mix formula is completed

ISSA Technical Bulletin 102 is used to estimate the approximate proportioning

In this test, a matrix of mix recipes is prepared and the manual mixing time is recorded for each mixture. A minimum time is required to ensure that the mixture will be able to mix without breaking in the microsurfacing slurry machine. At this stage, phenomena such as foaming and coating are visually assessed and the water and additive contents required to produce a quality mixture can be determined

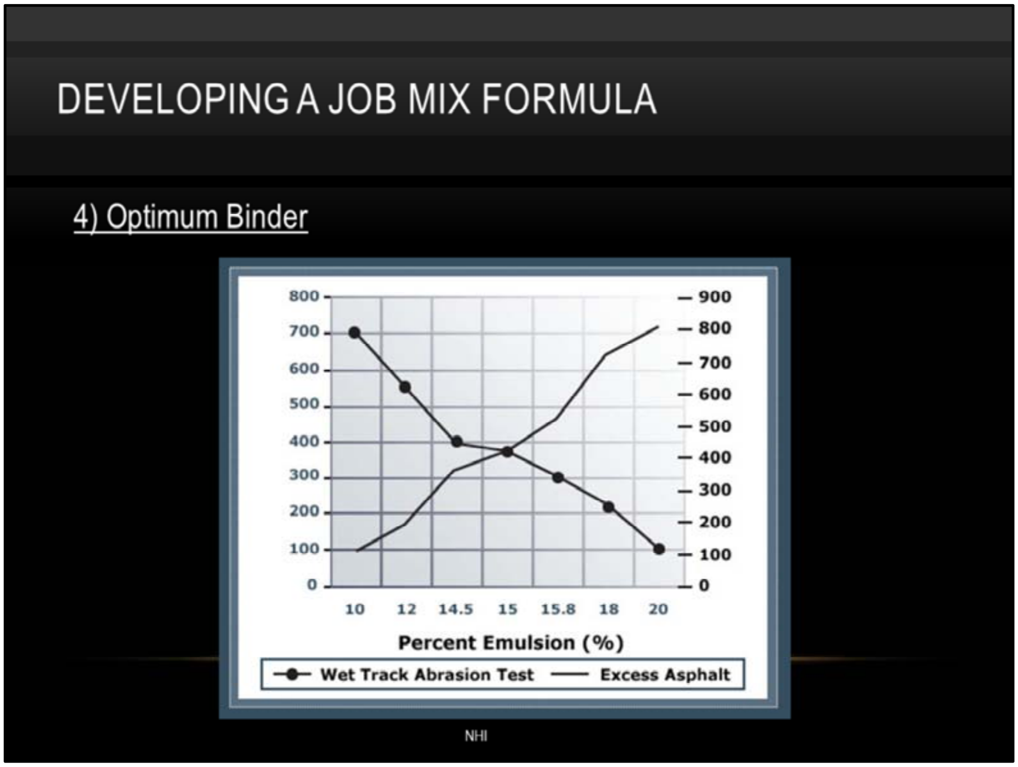
The process may be repeated at elevated or reduced temperatures to simulate expected field conditions at the time of application. The best mix is selected using aggregate coating as the prime criterion among those alternative designs whose mixing time exceeded the minimum across the expected temperature range.

Cohesion Build-up
Once the emulsion content is determined, three mixes are then made, one at the selected emulsion percentage from above, one at -2% of the selected emulsion content and one at +2% of the selected emulsion content. This allows a bracketing of the desired mix proportions. The ISSA test method detailed in TB 139 (5) is used to determine the cohesion build-up in a slurry mixture. This test may be performed at the expected field temperatures to provide the most accurate estimate of the treatment's characteristics

Abrasion Resistance
Mixes are made at three emulsion contents, optimum, optimum +2%, and optimum -2%. These mixes are then cured in circular molds for 16 hours at 60°C (140°F). The samples are then soaked for either 1 hour or 6 days, depending on the abrasion test (TB 100) (5) and the material. Microsurfacing requires 1-hour and 6-day soaking periods. Slurry design requires only a 1-hour soaking. After soaking, a standard rubber hose is orbitally ground over the surface of the sample (while still submerged) for a set period of time. The wear loss is then calculated.

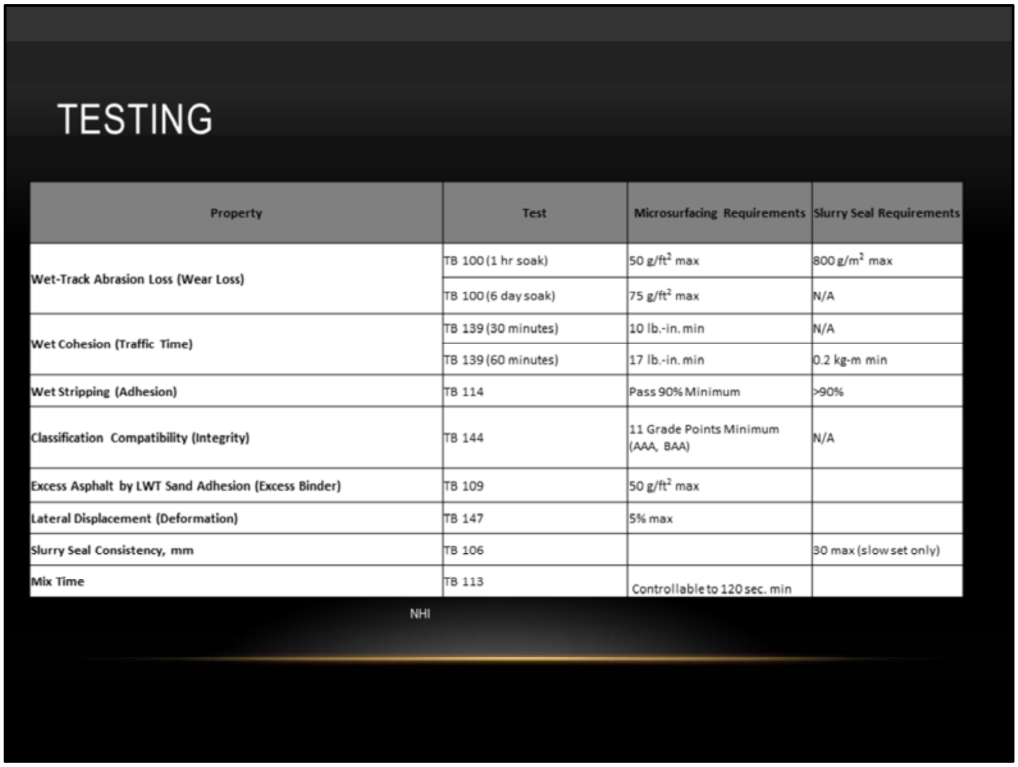
Upper Binder Limit
The upper binder limit is determined through the use of a deformation measurement. The Loaded Wheel Tester (LWT), the ISSA test procedure detailed in TB 147 (5), is used for the deformation measurement. In this test, a loaded wheel is placed on a cured strip of the mixture and the surface is tested. Once the surface has been tested, hot sand is poured onto the surface and the sample is then retested. When the second round of testing is

complete, the amount of sand retained on the sample is measured. This provides a measure of the free asphalt on the surface of the sample.



Optimum Binder

The optimum percentage emulsion or binder content is found by plotting the results obtained from the Wet Track Test (TB 100) and the Excess Binder Test (TB 109) (5). The optimum binder content is close to the intersection of the two plotted lines, but the testing does not account for all the factors influencing the mix. For example, the optimum binder content at the intersection of the plotted results is adjusted for the expected traffic conditions. A rule of thumb is to select the highest binder content that passes both tests for low traffic conditions and the lowest binder content for heavy traffic conditions. Note that this requires an experienced designer to select the optimum and this must be based on field knowledge and experience. This is a weakness in the current design process. The process demands an experienced designer to select the optimum binder.



Property	Test	Microsurfacing Requirements	Slurry Seal Requirements
Wet-Track Abrasion Loss (Wear Loss)	TB 100 (1 hr soak)	50 g/ft^2 max	800 g/m^2 max
	TB 100 (6 day soak)	75 g/ft^2 max	N/A
Wet Cohesion (Traffic Time)	TB 139 (30 minutes)	10 lb.-in. min	N/A
	TB 139 (60 minutes)	17 lb.-in. min	0.2 kg-m min
Wet Stripping (Adhesion)	TB 114	Pass 90% Minimum	>90%
Classification Compatibility (Integrity)	TB 144	11 Grade Points Minimum (AAA, BAA)	N/A
Excess Asphalt by LWT Sand Adhesion (Excess Binder)	TB 109	50 g/ft^2 max	
Lateral Displacement (Deformation)	TB 147	5% max	
Slurry Seal Consistency, mm	TB 106		30 max (slow set only)
Mix Time	TB 113	Controllable to 120 sec. min	

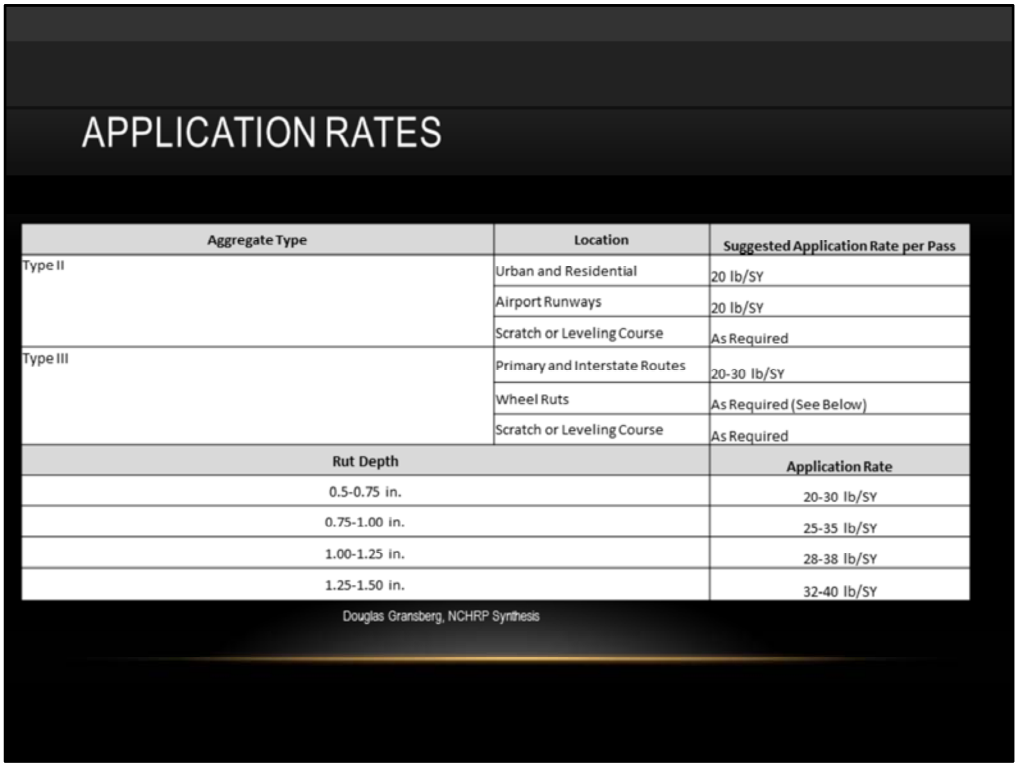
<u>Final Testing</u>

Final testing is conducted after a prospective mix formula is found to ensure the mix passes all of the above tests. The emulsion content and aggregate grading are reported as the job mix formula. Often adjustments need to be made in the field to account for environmental variables. Adjustments are limited to the amount of additives and water content required to ensure a good homogenous mixture.

*Not all tests required are listed here in on this slide. Please be sure to check your specification for a full list.

Slurry Seal	
Test	*Results*
Test Method for Wet Track Abrasion of Slurry Surfaces (ISSA TB-100 & ASTM D 6910)	*Measures the wearing qualities of the slurry seal mixture and determines the minimum asphalt content.*
Measurement of Slurry Seal Consistency (ISSA TB-106)	*Determines the amount of water to form a stable workable mixture.*
Test Method of Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded Wheel Tester and Sand Adhesion (ISSA TB-109)	*Measures resistance of asphalt in cured slurry seal from flushing to the surface and determines maximum asphalt content when the mixture is to be applied in heavy-traffic applications.*
Trial Mix Procedure for Slurry Design (ISSA TB-113)	*Provides insight into the visual appearance and mechanical properties of potential mixtures.*
Wet Stripping Test for Cured Slurry Seal Mix (ISSA TB-114)	*Aids in selection of a compatible slurry system with a given aggregate.*
Determination of Slurry System Compatibility (ISSA TB-115)	*Evaluates compatibility and aids in determining cure.*
Test Method to Classify Emulsified Asphalt/Aggregate Mixture Systems by Modified Cohesion Tester Measurement of Set and Cure Characteristics (ISSA TB-139 & ASTM D 3910)	*Defines the "set time" and "early rolling traffic time" of the mixture. (This test does not apply to slow set/slow traffic systems.)*
Bulk Density Test Set (ASTM C 29 & AASHTO T 19)	*Reports the quantitative effects of moisture content on the unit weight of aggregate (bulking effect).*
Microsurfacing	
Test	*Results*
Test Method for Wet Track Abrasion of Slurry Surfaces (ISSA TB-100 & ASTM D3910)	*Measures the wearing qualities of the microsurfacing mixture and determines the minimum asphalt content.*
Test Method of Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded Wheel Tester and Sand Adhesion (ISSA TB-109)	*Measures resistance of asphalt in cured microsurfacing from flushing to the surface and determines maximum asphalt content when the mixture is to be applied in heavy-traffic applications.*
Trial Mix Procedure for Slurry Design (ISSA TB-113)	*Provides insight into the visual appearance and mechanical properties of potential mixtures.*
Wet Stripping Test for Cured Slurry Seal Mix (ISSA TB-114)	*Aids in selection of a compatible slurry system with a given aggregate.*
Test Method to Classify Emulsified Asphalt/Aggregate Mixture Systems by Modified Cohesion Tester Measurement of Set and Cure Characteristics (ISSA TB-139 & ASTM D 3910)	*Defines the "set time" and "early rolling traffic time" of the mixture.*
Test Method for Classification of Aggregate Filler-Bitumen Compatibility by Schulze-Breuer and Ruck Procedures (ISSA TB-144)	*Determines the relative compatibility between aggregate filler 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-147)	*Measures the amount of compaction or displacement of cold mixes under simulated rolling traffic.*
Bulk Density Test Set (ASTM C 29 & AASHTO T 19)	*Reports the quantitative effects of moisture content on the unit weight of aggregate (bulking effect).*

ISSA



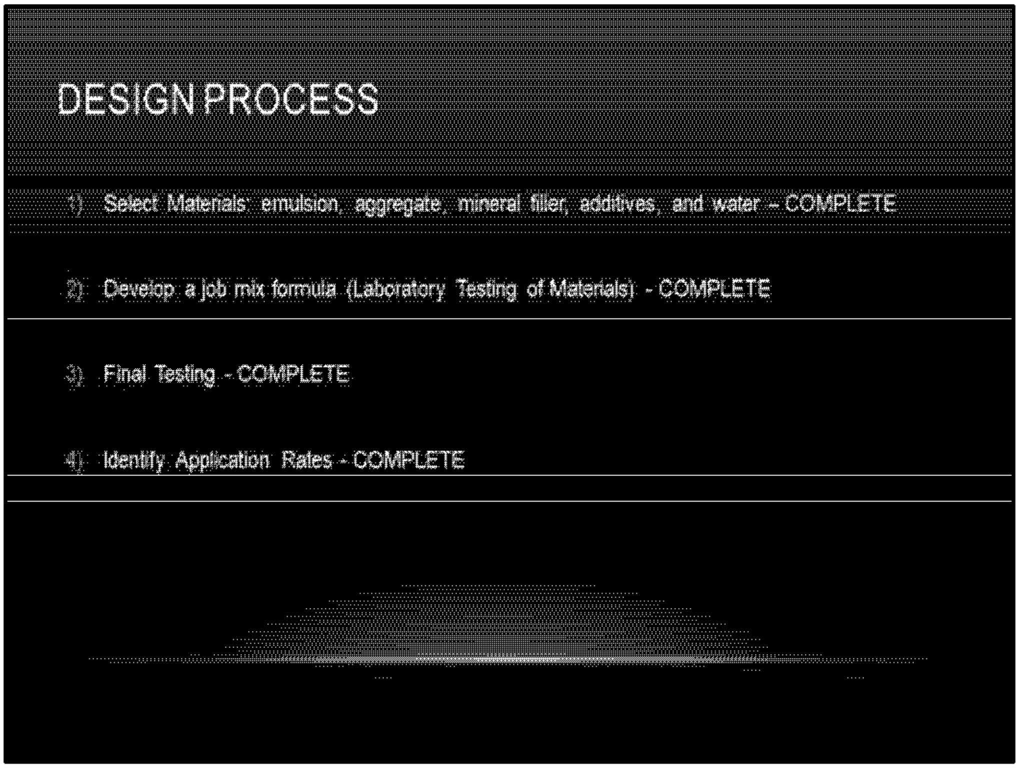
Aggregate Type	Location	Suggested Application Rate per Pass
Type II	Urban and Residential	20 lb/SY
	Airport Runways	20 lb/SY
	Scratch or Leveling Course	As Required
Type III	Primary and Interstate Routes	20-30 lb/SY
	Wheel Ruts	As Required (See Below)
	Scratch or Leveling Course	As Required
Rut Depth		**Application Rate**
0.5-0.75 in.		20-30 lb/SY
0.75-1.00 in.		25-35 lb/SY
1.00-1.25 in.		28-38 lb/SY
1.25-1.50 in.		32-40 lb/SY

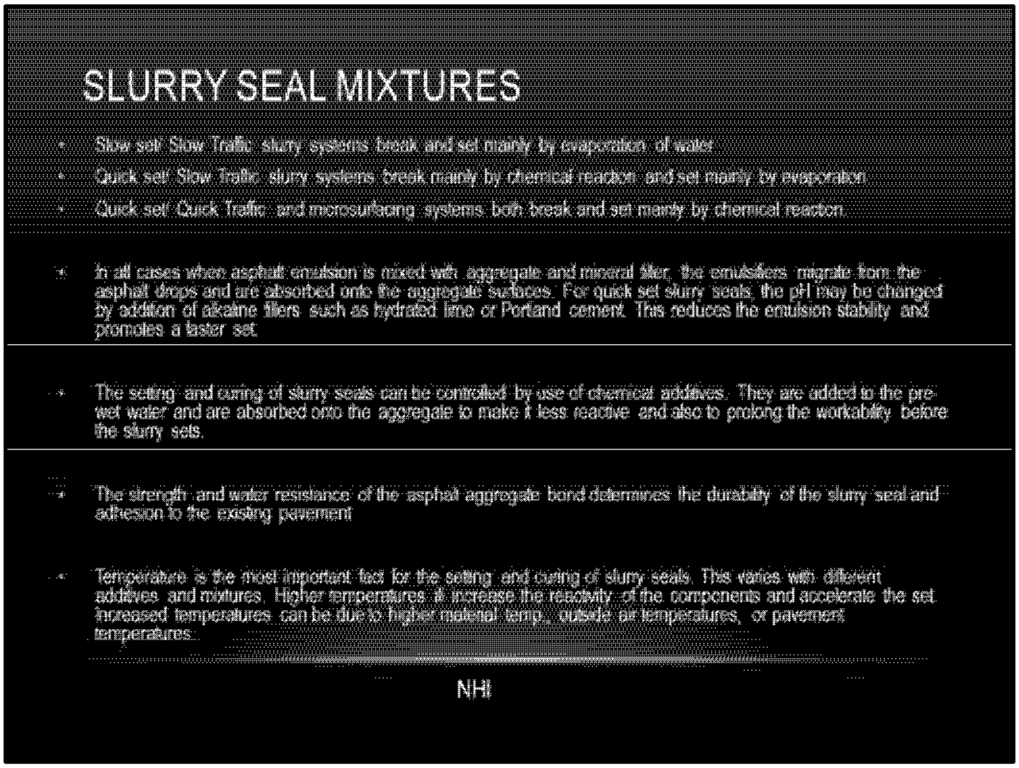
- Excessive application rates may cause the mix to segregate and leave a flushed or excessively smooth surface texture. If the engineer needs to exceed the stated maximum application rates, the microsurfacing is then placed in multiple lifts

- Base application rates are given and suggested, but many times application rates are modified on-site to accommodate for surface and environmental conditions.

- The two main factors in determining application rates are aggregate gradation and existing surface texture.
    - Coarser aggregate = thicker application
    - More porous a surface = more material must be placed

- Iowa DOT spec recommends a rate of 20 lbs/SY


DESIGN PROCESS
1) Select Materials: emulsion, aggregate, mineral filler, additives, and water – COMPLETE
2) Develop a job mix formula (Laboratory Testing of Materials) - COMPLETE
3) Final Testing - COMPLETE
4) Identify Application Rates - COMPLETE

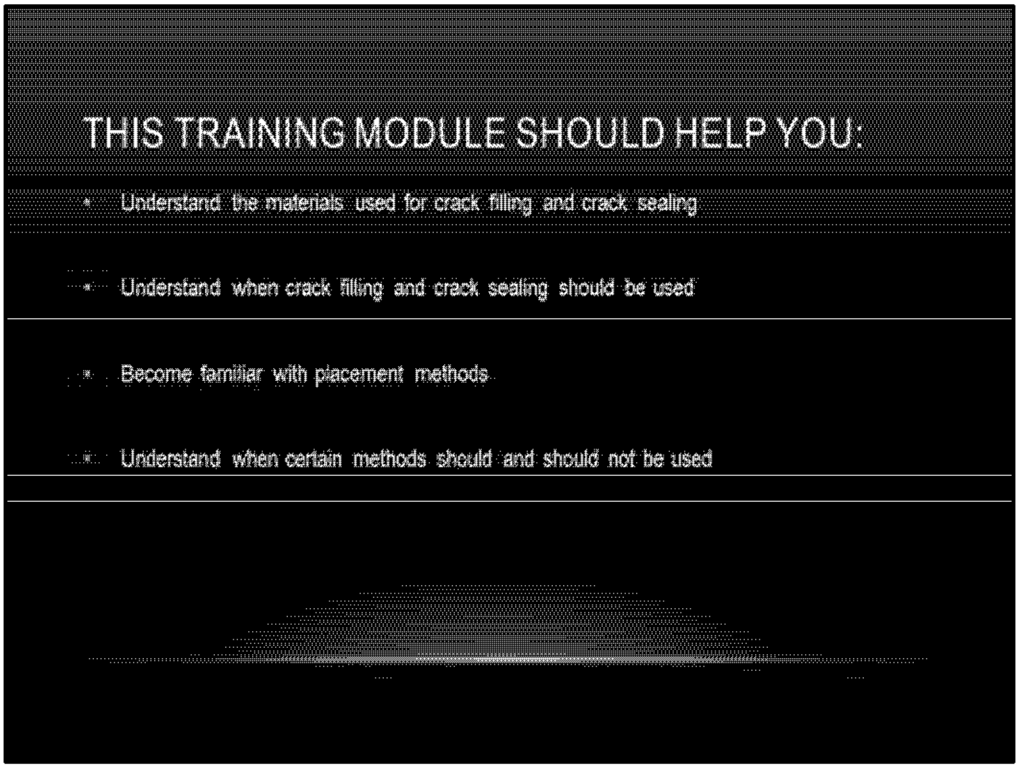

SLURRY SEAL MIXTURES
Slow set/ Slow Traffic slurry systems break and set mainly by evaporation of water
Quick set/ Slow Traffic slurry systems break mainly by chemical reaction and set mainly by evaporation
Quick set/ Quick Traffic and microsurfacing systems both break and set mainly by chemical reaction
In all cases when asphalt emulsion is mixed with aggregate and mineral filler, the emulsifiers migrate from the asphalt drops and are absorbed onto the aggregate surfaces. For quick set slurry seals, the pH may be changed by addition of alkaline fillers such as hydrated lime or Portland cement. This reduces the emulsion stability and promotes a faster set.
The setting and curing of slurry seals can be controlled by use of chemical additives. They are added to the pre-wet water and are absorbed onto the aggregate to make it less reactive and also to prolong the workability before the slurry sets.
The strength and water resistance of the asphalt aggregate bond determines the durability of the slurry seal and adhesion to the existing pavement
Temperature is the most important fact for the setting and curing of slurry seals. This varies with different additives and mixtures. Higher temperatures will increase the reactivity of the components and accelerate the set. Increased temperatures can be due to higher material temp., outside air temperatures, or pavement temperatures.
NHI

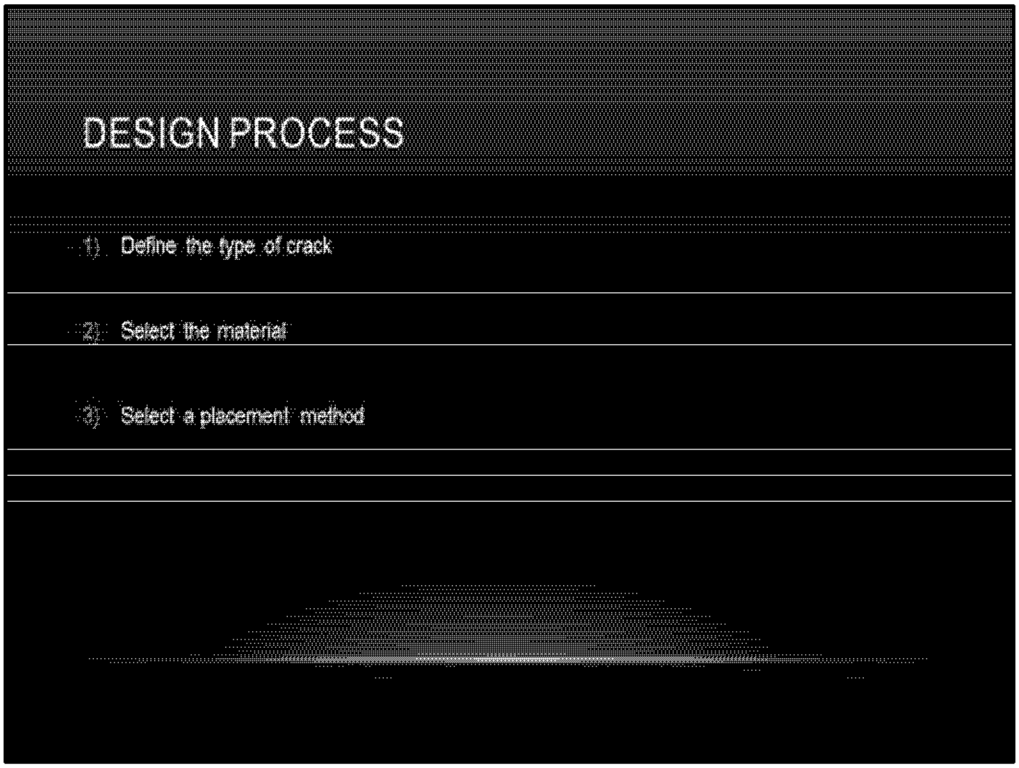
MICROSURFACING MIXTURES

- Microsurfacing is a mixture of:
  - Polymer Modified emulsified asphalt
  - Dense-graded 100% crushed mineral aggregate
  - Mineral filler (portland cement)
  - Liquid additives (emulsifying agent)
  - Water
- The components are very similar to hot-mix asphalt, but microsurfacing can be placed cold and in much thinner lifts
- The Portland cement acts as an accelerator for the breaking time of the asphalt emulsion. The additives are used to control break time when the material is place during hot weather.

NHI

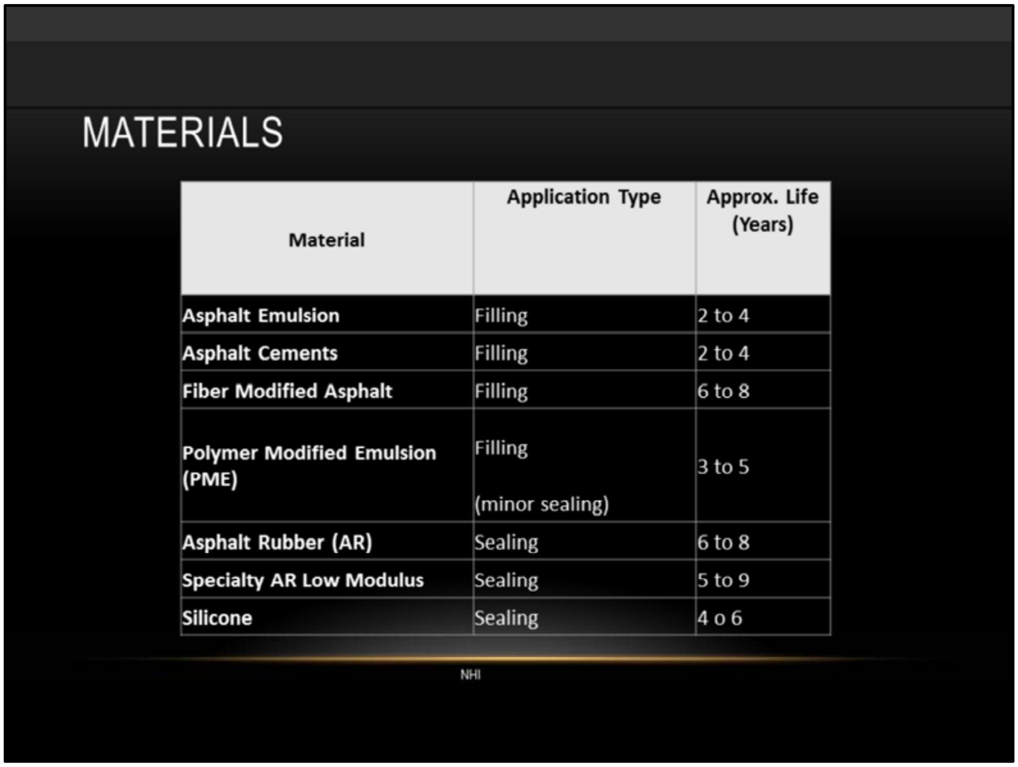

PAVEMENT PRESERVATION:
DESIGN – CRACK FILL/SEAL


THIS TRAINING MODULE SHOULD HELP YOU:
Understand the materials used for crack filling and crack sealing
Understand when crack filling and crack sealing should be used
Become familiar with placement methods
Understand when certain methods should and should not be used


DESIGN PROCESS
1) Define the type of crack
2) Select the material
3) Select a placement method

CRACK FILL OR SEAL?

Crack Characteristics	Crack Treatment Activity	
	Crack Sealing	Crack Filling
Edge Deterioration	Minimal to None (<25% of crack length)	Moderate to None (<50% of crack length)
Annual Horizontal Movement	>= 1/8 in. (Working)	< 1/8 in. (Non-working)
Type of Crack	Transverse Thermal Cracks Transverse Reflective Cracks Longitudinal Reflective Cracks Longitudinal Cold Joint Cracks	Longitudinal Reflective Cracks Longitudinal Cold Joint Cracks Longitudinal Edge Cracks Distantly Spaced Block Cracks



MATERIALS

Material	Application Type	Approx. Life (Years)
Asphalt Emulsion	Filling	2 to 4
Asphalt Cements	Filling	2 to 4
Fiber Modified Asphalt	Filling	6 to 8
Polymer Modified Emulsion (PME)	Filling (minor sealing)	3 to 5
Asphalt Rubber (AR)	Sealing	6 to 8
Specialty AR Low Modulus	Sealing	5 to 9
Silicone	Sealing	4 o 6

NHI

*Review Specification Section 2544 along with this table. Not all materials listed are listed in Iowa DOT specification.

Materials for Crack Sealing

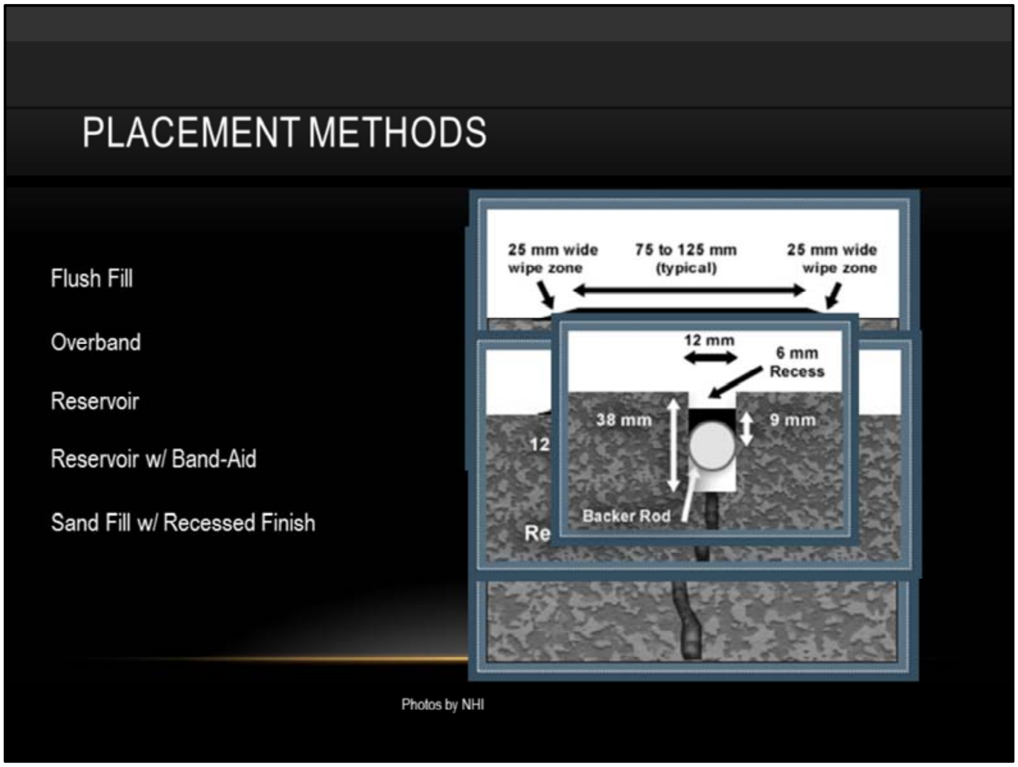
Crack sealing materials are designed for three main functions: to adhere to the walls of the crack, stretch with the movement of the crack over the range of conditions and loads associated with the crack location, and resist abrasion and damage caused by traffic. For sealing working cracks, the preferred sealant is usually elastomeric. This means the sealant has a low modulus of elasticity and will stretch easily to high elongations (usually around 10 times its non-strained dimensions) without fracture. Such sealants also recover over time to close to their original dimensions. Sealants are usually applied at elevated temperatures due to their high viscosity at ambient temperatures and they have a thermoplastic property that allows them to set or cure by cooling and reforming into complex structures. These materials are sometimes incorrectly referred to as thermosets, a term that describes materials that undergo chemical cross-linking when heated. Such materials have structures that are retained with cooling and are not reversible by reheating. Thermoplastics form physical structures on cooling, but this process is reversible with reheating. Hot application ensures good adhesive bond to the crack walls.
Cold poured materials for crack sealing are usually silicone-based and often used prior to paving. These materials cure either by exposure to moisture in the air, or by mixing a hardening agent with the base silicone. They often have poor abrasion resistance and should not be used in trafficked areas. Other materials such as epoxies and polyurethanes are almost always cured by addition of a second chemical.

Materials for Crack Filling

For crack filling applications, the cracks are basically inactive (non-working). Crack filling materials are designed to adhere to the walls of the crack, and resist abrasion and damage caused by traffic.

Crack filling materials may be hot applied rubber or polymer asphalts, or cold applied emulsion-based products. The emulsion products assist with forming a good adhesive bond with the crack wall and additives such as Styrene Butadiene Rubber (SBR) latex ensure that the material can endure some degree of movement. In some cases, hot applied fiber modified asphalt binders may be used.

*Materials for non-working cracks will not be sufficient for working cracks



Flush Fill
In the flush fill method, fill material is forced into an existing uncut crack. Once filled, the crack is struck off flush with the pavement.

Overband
- In the overband method, fill material is forced into and placed over an uncut crack. If the fill material is squeegeed flat, it is referred to as a 'Band-Aid'; if not; it is referred to as capped. Overbanding and capping should not be done if silicone has been chosen as the fill material. This is due to silicone's poor abrasion resistance.
- The capped overband method is not recommended. All crack sealing and filling should be squeegeed if material is left above the surface. Overbanding can create a rough ride and/or excess road noise and causes problems when placing subsequent overlays.

Reservoir
In the reservoir method, the crack is cut or routed to form a reservoir that is filled with a sealant. The sealant may be left flush or slightly below the surface of the reservoir. The depth and width of the reservoir varies according to job requirements. Saw depths will be greatest when working with very active cracks and cracks in PCC pavements. Crack cutting will often depend on the number of cracks and whether the cutter can follow the shape of the crack. Typical reservoir widths range from 12 to 25 mm (0.5 to 1.0 in), and even up to 38 mm (1.5 in) in very cold climates. Reservoir depth ranges from 12 to 25 mm (0.5 to 1.0 in). Reservoir use is appropriate for pavements in good condition without extensive cracking. Crack cutting units, when operated by trained, experienced personnel, can follow

meandering random cracks.

Reservoir with Band-aid

This combination method involves the formation of a Band-Aid over the top of a cut reservoir. Figure 14 illustrates the combination method. Like the overband method, the combination method should not be used with materials that are prone to pickup due to traffic or materials with poor wearing characteristics (3). The combination method can be used on heavily trafficked roads, but care must be taken to squeegee excess material off the surface.

Sand Fill w/ Recessed Finish

Thermal cracking can develop over time and penetrate the full depth of asphalt pavement in a roadway. As thermal cracks progress down through the asphalt layers, they typically continue to widen. It is not unusual for such cracks to be 12 to 25 mm (0.5 to 1 in) or wider and exceed 102 mm (4 in) in depth. If these types of cracks are sealed or filled full depth, the large volumes of filler or sealer tend to soften and migrate under loads in hot weather and begin to pull out under traffic. If an overlay is applied, the heat of the new mat will draw the filler and sealer materials up through the overlay. In areas with heavy sealer or filler applications, fat spots, flushing, and shoving in the overlay can occur. These symptoms can only be remedied by changes in construction procedures or the removal and replacement of the affected materials.

Sealant application should not exceed 25 mm (1 in) in depth. For full depth wide cracks, backer rod can be used to limit sealant depth. Another method is to partially fill the crack with sand. Blow out any debris with air, fill the crack with clean sand to a point approximately 19 to 25 mm (0.75 to 1 in) below the adjacent pavement surface, and tamp lightly as needed with a steel rod or piece of rebar to reduce any large voids in the sand. Then apply the crack sealer over the top of the sand and along the crack faces. The surface of the sealant should be cupped slightly below the adjacent pavement surface. This recessed finish allows some movement of the crack and sealer material without creating an undesirable hump on the surface. It fills and seals the deep wide crack while limiting the impact on subsequent paving operations.

Backer Rod

Joint sealing applications for PCC pavements may require the incorporation of a backer rod or bond breaker. The backer rod, typically polyethylene foam, is placed within a crack or joint to prevent the sealant from sticking to the reservoir bottom and to restrict the sealant depth to the upper portion of the joint. A backer rod is also incorporated in very large cracks or joints, particularly when a self-leveling silicone is being used. A backer rod is only used if it is cost effective and the cracks are relatively straight like those occurring in PCC joints

WHEN TO USE PLACEMENT METHODS

Project Consideration	Method Applicability
Type and Extent of Operation	Most filling operations and some sealing operations omit crack cutting. However, many northern states have found crack cutting necessary and desirable for cracks exhibiting significant movements.
Traffic	Overband configurations experience wear and subsequently high tensile stresses directly above the crack edges, leading to adhesive edge separations. Thus, overband configurations should be avoided for sealing cracks on heavily trafficked roads.
Crack Characteristics	Overband configurations are appropriate for cracks having a considerable amount of edge deterioration (> 10 percent of crack length) because the overband simultaneously fills and covers the deteriorated segments in the same pass. Reservoir methods without overbanding should not be used on cracks with edge deterioration.
Material Type	Materials such as emulsion, asphalt cement, and silicone must be placed unexposed to traffic due to serious tracking or abrasion problems.
Desired Performance	For long-term sealant performance where ride quality is an important consideration, the flush reservoir and recessed band-aid configurations provide the longest life.
Aesthetics	Overband and combination configurations detract from the general appearance of the pavement.
Cost	Omission of the crack cutting operation reduces equipment and labor costs but may decrease treatment longevity. Combination configurations require significantly more material than reservoir configurations, resulting in higher costs. The placement method impacts the type of material to use as well so costs may be higher for specialty materials

NHI

The appropriate placement method should be based on a project's governing considerations such as:

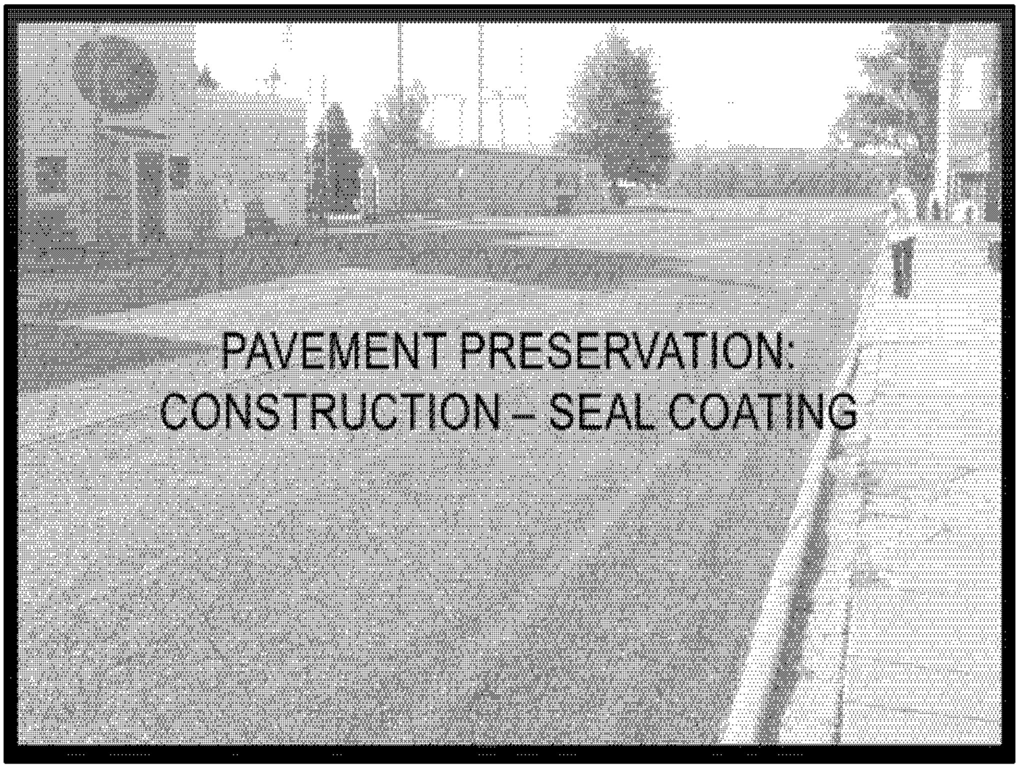
1. Type and extent of the sealing or filling operation
2. Traffic conditions
3. Crack characteristics
4. Material requirements
5. Desired performance or expectations
6. Aesthetics
7. Cost

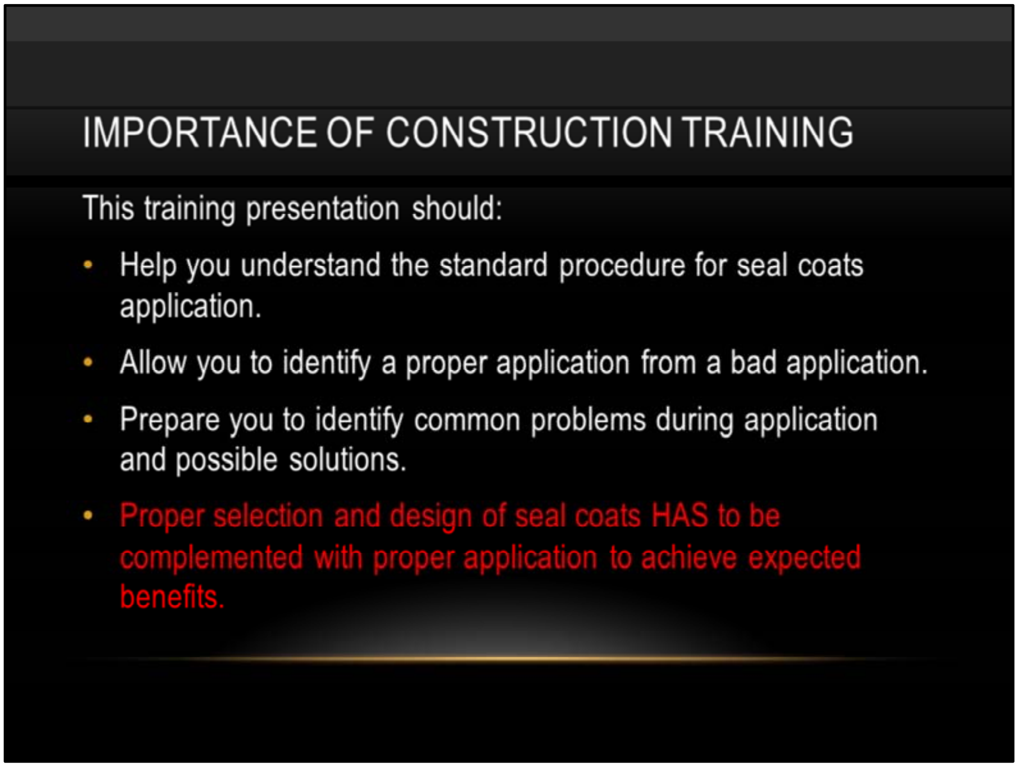
SUMMARY

1) Is the Crack Working or Non-working? (Crack Fill or Seal)

2) Select Material

3) Select a Placement Method


PAVEMENT PRESERVATION:
CONSTRUCTION – SEAL COATING



Why would you need this training??

- We hope this presentation gives you some basic information on the construction process of seal coats.
- You may have heard of this before, or worked on a similar project, so this might just help you refresh your mind.
- Red bullet point is KEY.

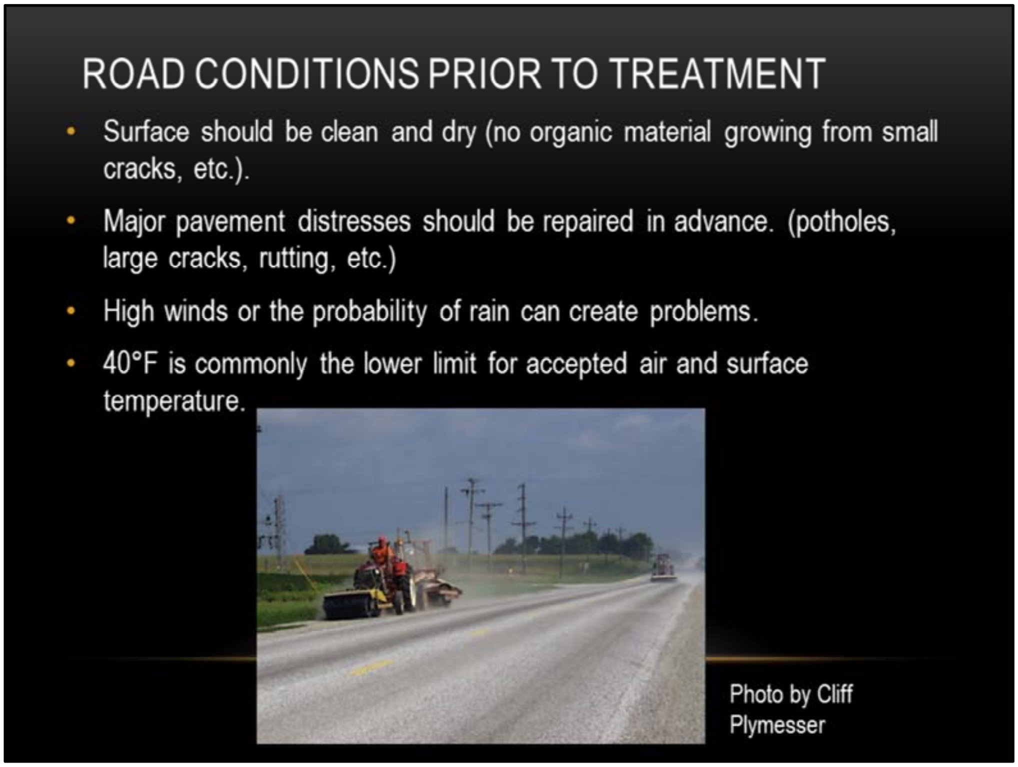
Basically seal coats consist of a layer of asphalt binder followed by a layer of aggregate to provide skid resistance.

Lets keep in mind that seal coats are not recommended for fixing major distresses like large cracks, pot holes or rutting problems.

Although they are typically used in low volume roads, there are cases where they have been used for average to high volume roads with low speeds.

To address some of the disadvantages of seal coats, some measures could be taken like:
- Using precoated aggregates that helps reduce dust
- Applying a layer of fog seal to keep the aggregates in place

More examples can be found in other modules.



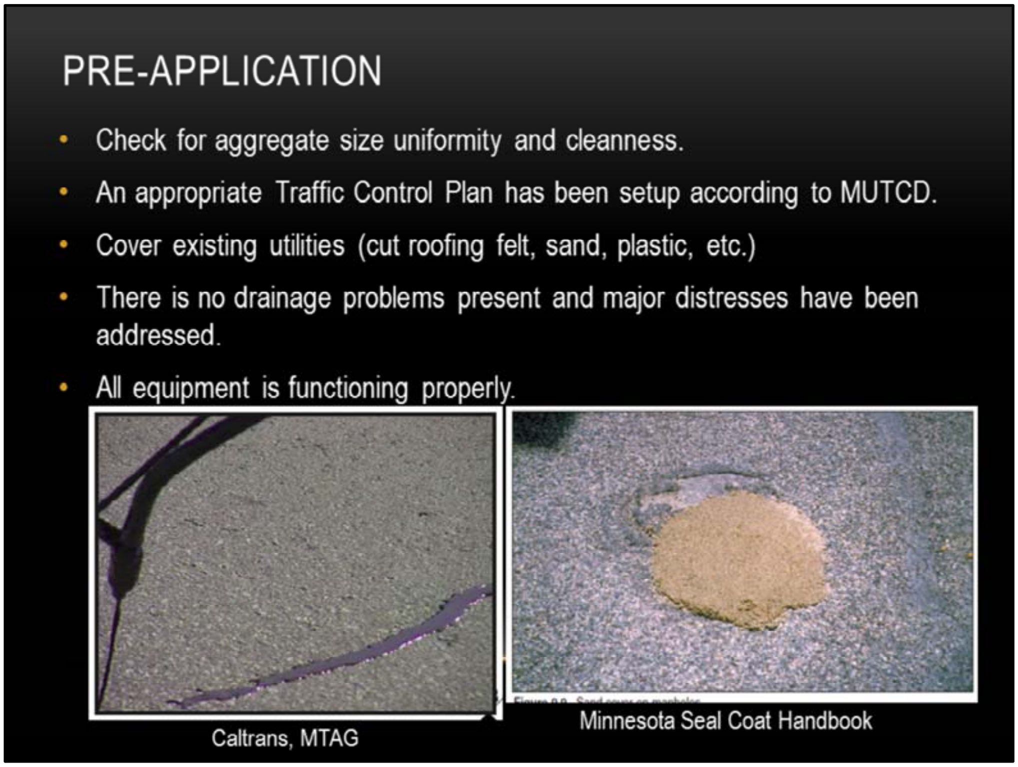
Prior to treatment the road should be prepared and the team should be conscious of their setting.

It could be a good idea to broom the surface before application to clear the surface from any loose material loose aggregates.

As said before, major distresses need to be repaired before hand, since the seal coat application will not fix them.

The team should be alert of some no-go condition as for example:

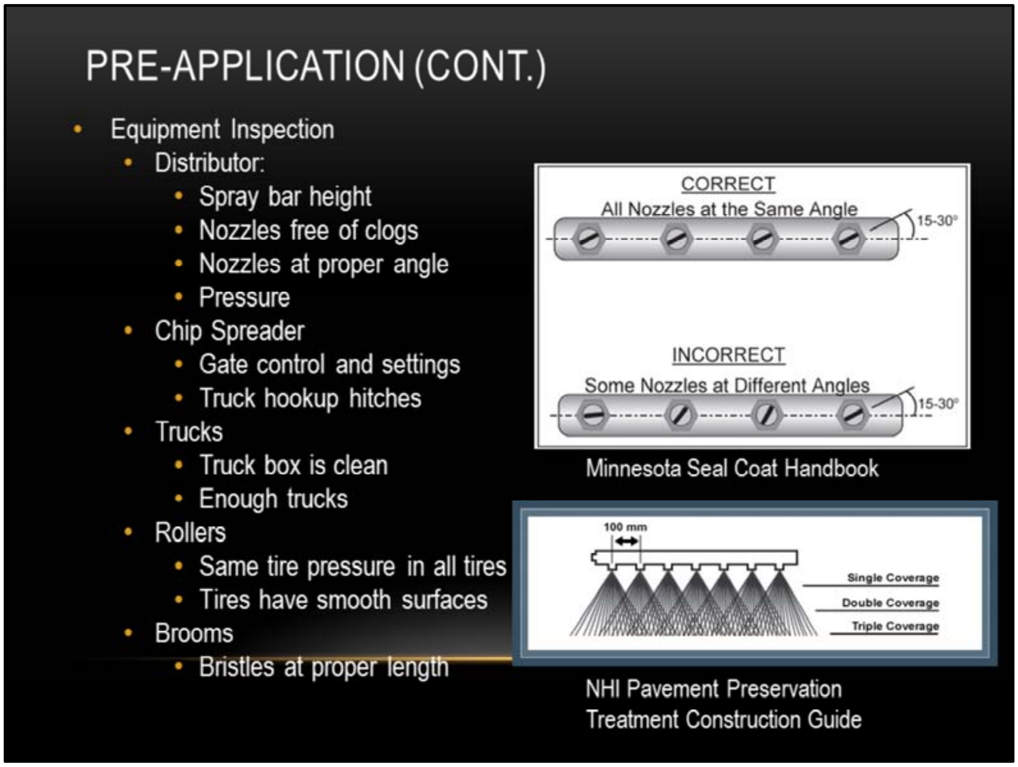
- High winds that may alter the binder spray angle and coverage
- Probability of rain
- temperature



According to the Minnesota Seal Coat Handbook using sand to cover manholes is the preferred method since the material has to be disposed properly.

We do not want water or humidity in the road. Drainage problems will also cause binder to concentrate in some areas.

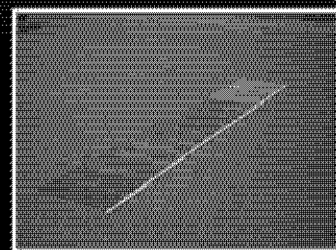
Video shows major cracks that were not corrected prior to treatment.
Although application appears to be uniform at the beginning, binder will slowly fill cracks leaving unembedded and exposed chips.
This could cause all kinds of problems to users as aggregate is loose and aggregates being dislodged by traffic (flyrock) can cause windshield damage.

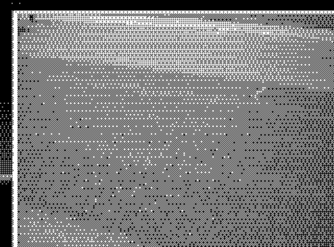


Refer to picture 1 to show the importance of proper nozzle angles.

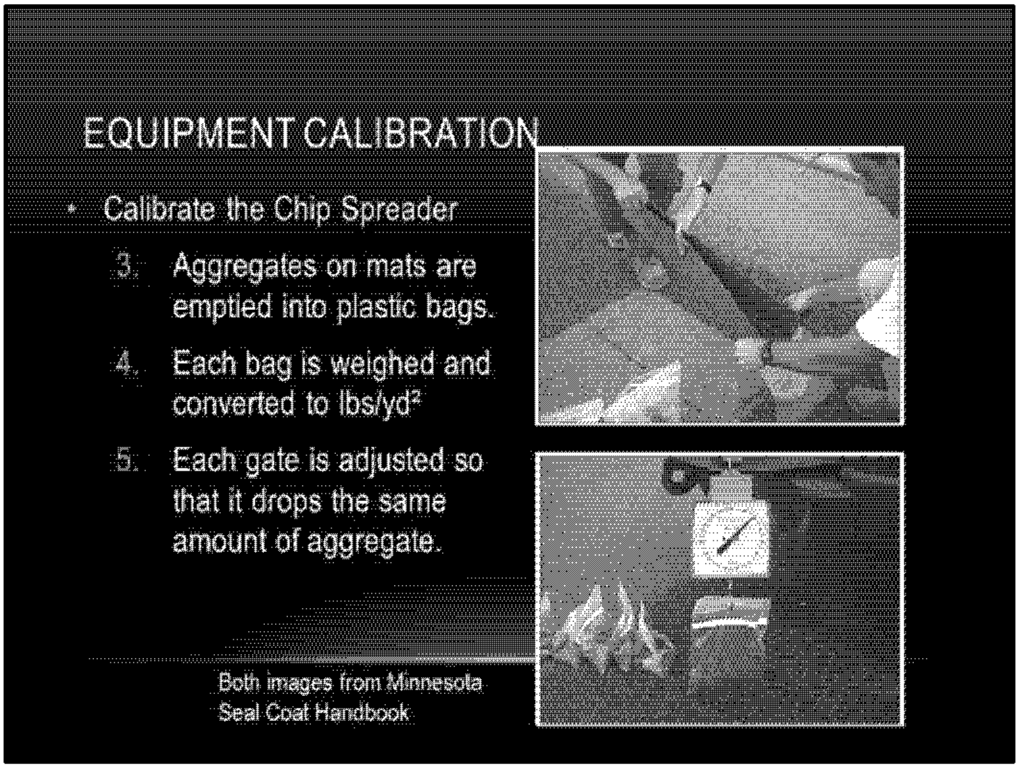
EQUIPMENT CALIBRATION

- Calibrate the Chip Spreader
  1. 1yd² rubber mats are laid on the roadway.
  2. Chip spreader drives over mat while dropping chips at application rate.





Both images from Minnesota Seal Coat Handbook

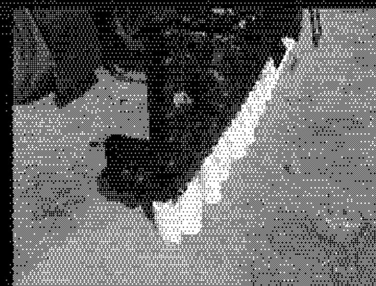

EQUIPMENT CALIBRATION
• Calibrate the Chip Spreader
3. Aggregates on mats are emptied into plastic bags.
4. Each bag is weighed and converted to lbs/yd²
5. Each gate is adjusted so that it drops the same amount of aggregate.
Both images from Minnesota Seal Coat Handbook

EQUIPMENT CALIBRATION

- Asphalt Distributor (NCHRP-680)

Lateral Calibration

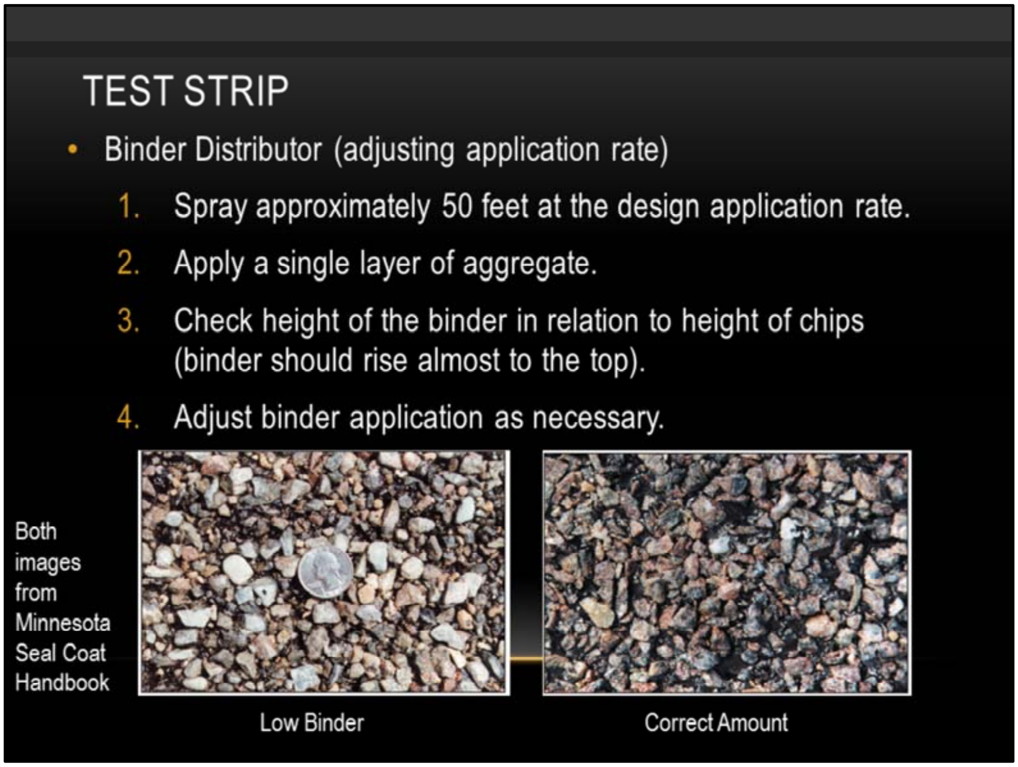
1. Place containers below each nozzle and apply emulsion until approximately 75% of each container is full.
2. Weigh each container and adjust so that they all fall within 10% of the average.



Webb (2010)

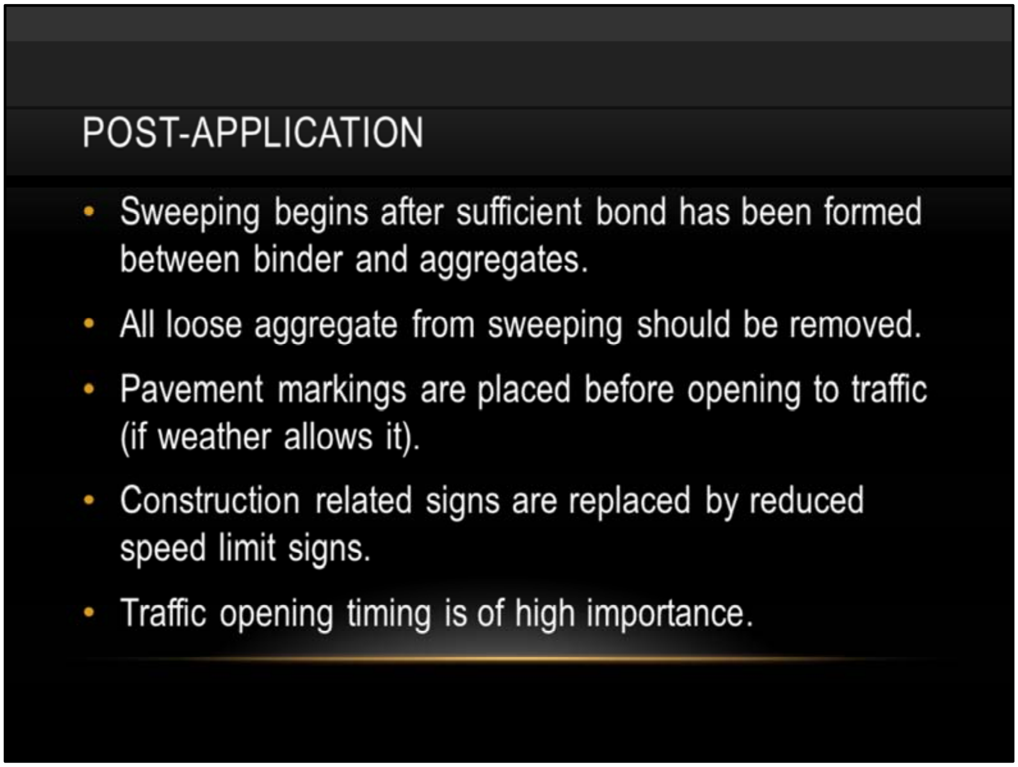
Longitudinal Calibration

1. Measure the initial and final volume in the tank of approximately a 50ft test section.
2. Compare the difference in volume in terms of gal/yd² with the design application rate.



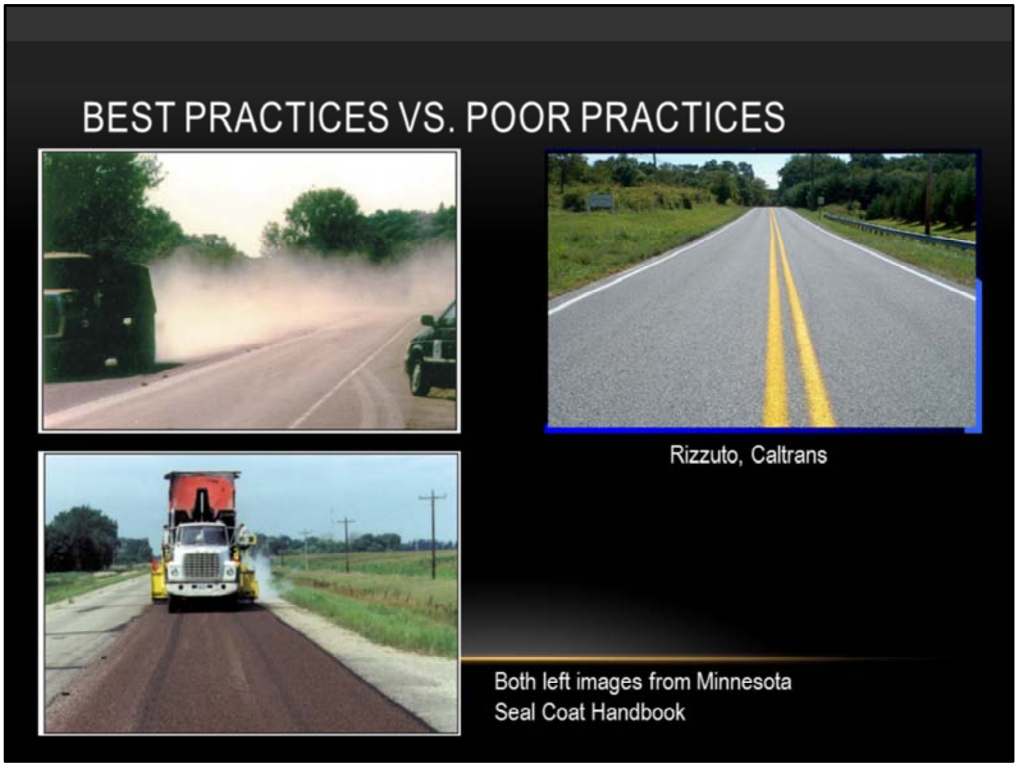
Trial and error approach.
We try to get to a point where the binder covers close to 50% of aggregate height, for a future 70% after embedment.

3 rollers would cover the width of the lane.



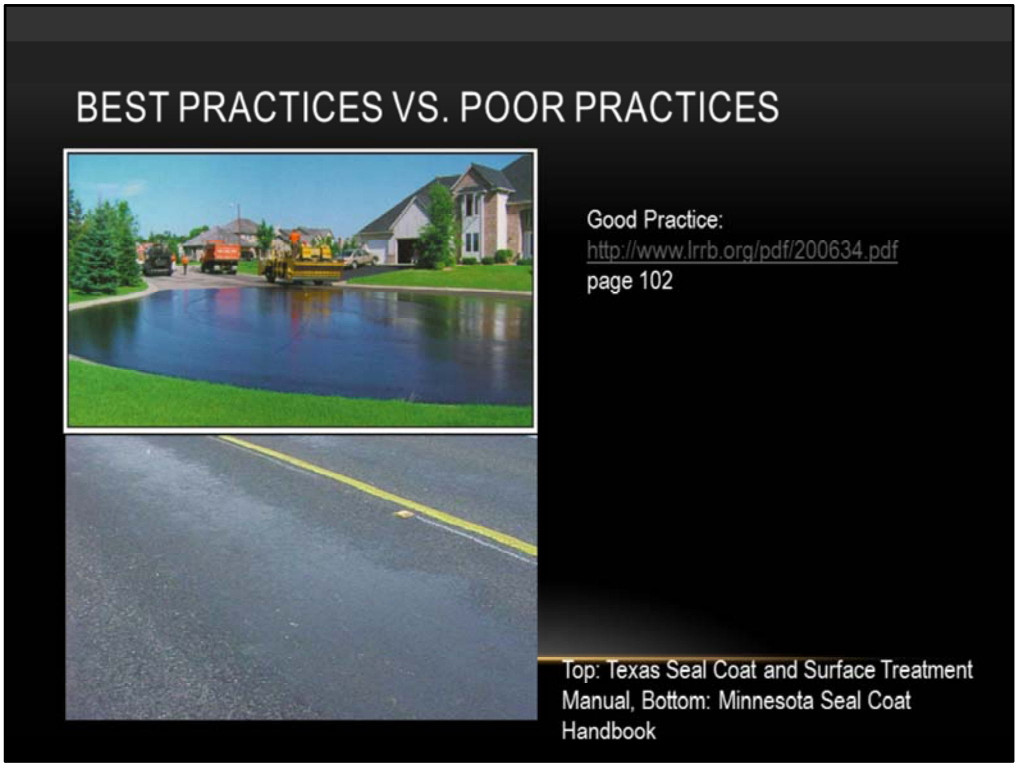
We want to keep the traffic at slow speed at the beginning to minimize the chances of aggregate getting dislodged.

A fog seal may be applied after a seal coat to keep chips in place, although this will cause low friction and delay the opening time.
I believe that here in Iowa it is common to apply a seal coat with a fog seal by alternating days. For example if a project starts on Monday then a seal coat is applied on a section on that day, then on Tuesday a fog seal is applied over the recently applied seal coat. Then on Wednesday seal coat continues on the next section, then Thursday fog seal, and so on.



Proper application – top right, uniform with no imperfections

Improper – top left, use of dusty aggregate with what appears to be low to no sweeping before opening. Also, it could be argued that the aggregates didn't pass the gradation test, too many fines. Or storage area was over fines, and during the scoop and dump some dusty aggregates or fines got mixed. bottom left, mix was too rich in binder or low in aggregate as binder is showing over the aggregate in the truck wheel path.



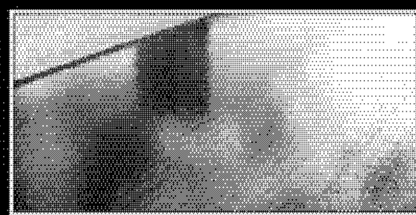
Roundabout incorrectly applied with seal coat since binder will start to cure before aggregate has been placed entirely.

High binder content caused quick bleeding.

COMMON PROBLEMS AND SOLUTIONS

- Problem: Streaked Appearance

  Solution: Adjust bar height, adjust nozzles angles or nozzles may be clogged

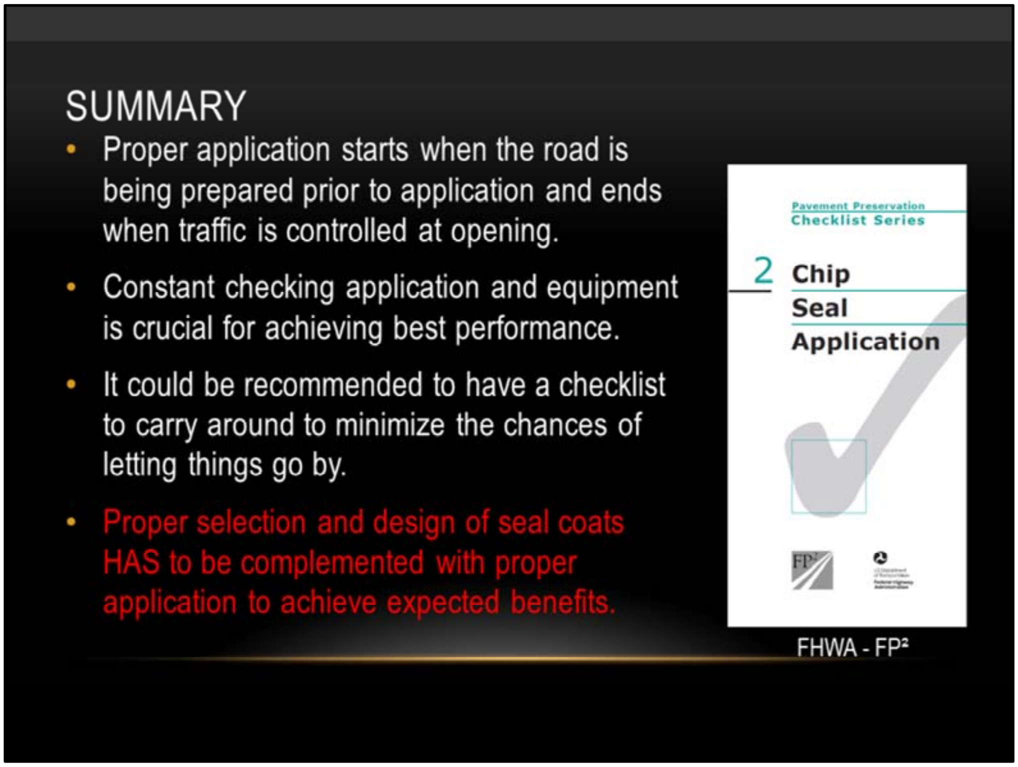


Minnesota Seal Coat Handbook

- Problem: Asphalt bleeding

  Solution: Reduce asphalt application rate


COMMON PROBLEMS AND SOLUTIONS (CONT.)
Problem: Loss of aggregate
Solution: apply more asphalt binder, improve rolling technique or change aggregate in use
Problem: Dislodged chips
Solution: decrease traffic speed, sweeping should start later, or aggregate is too dirty
Checklist and Troubleshooting Guide (NHI):



Application of seal coats start as soon as the road is being cleaned. With improper cleaning comes bad results.

Constant inspection for equipment malfunction, visual uniformity, and overall process is crucial for success.

Pavement Preservation checklists are available to help guide you through the process.


PAVEMENT PRESERVATION:
CONSTRUCTION – FOG SEALING
Image from Caltrans


IMPORTANCE OF CONSTRUCTION TRAINING
This training should help the viewer:
Understand the standard procedure for fog seal application.
Prepare for design adjustments on site.
Identify a proper application from a bad application.
Identify common problems during application and possible solutions.
Proper selection and design of fog seals HAS to be complemented with proper application to achieve expected benefits.

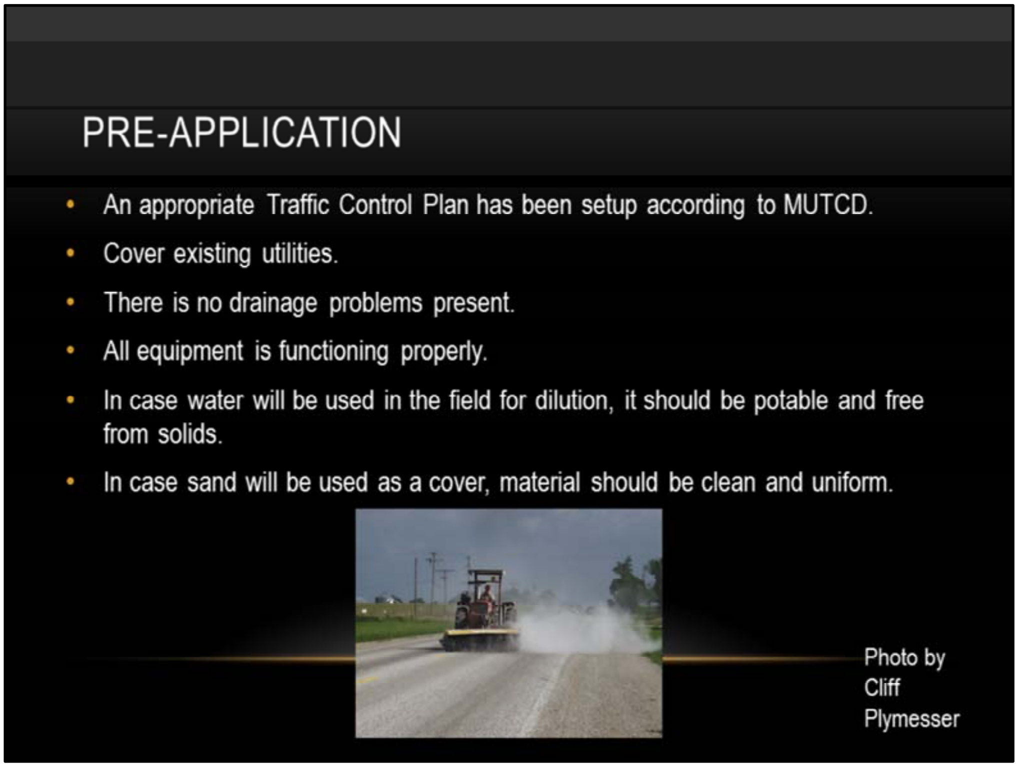
Another disadvantage goes along with the 2nd bullet, fog seals do not correct any major distresses.

If you are one of the construction guys in charge of applying or inspecting a fog seal, bullets 2 and 3 are important for you.

Clean since we want the binder to stick to the surface.
Dry since we want our mix to have a certain amount of water.

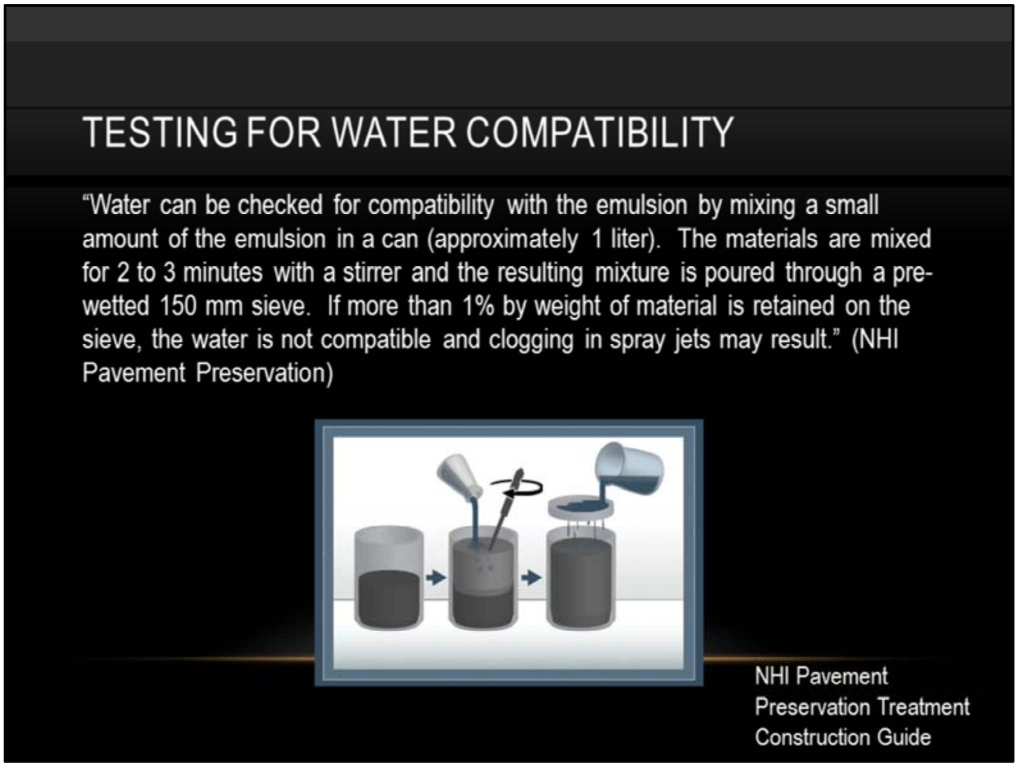
As said before a fog seal will not correct major distresses so these need to be repaired beforehand.

Temperatures below 60 will cause the emulsion to take longer to cure.

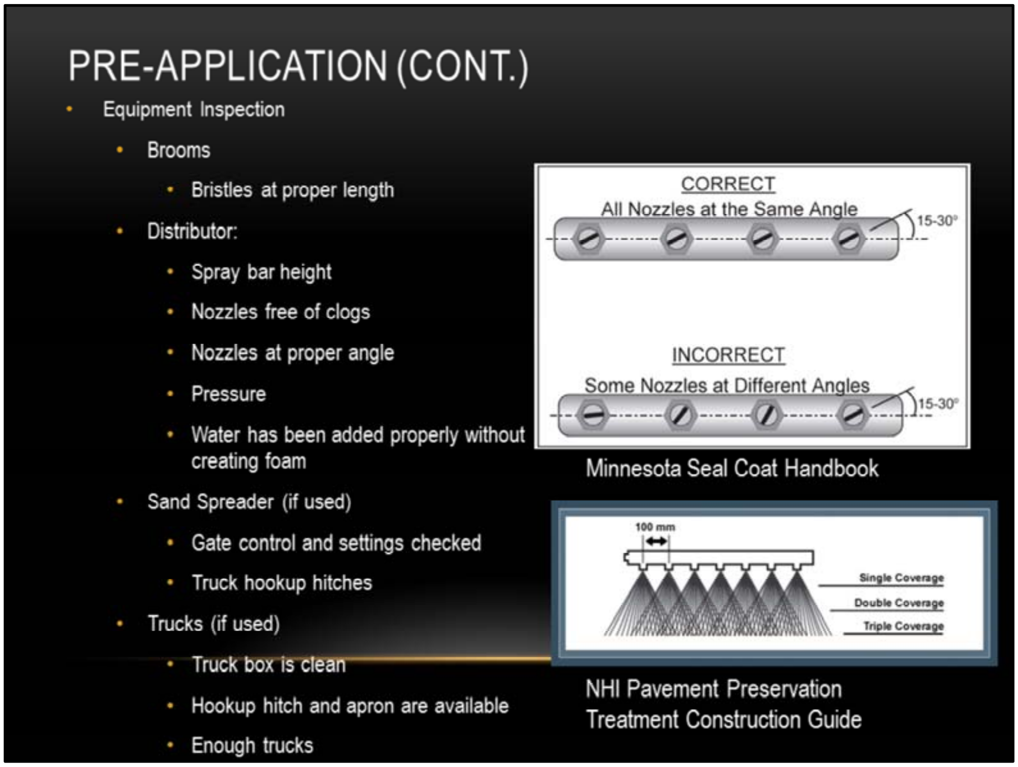


Drainage problems will cause the emulsion to concentrate in some areas, providing an uneven application.

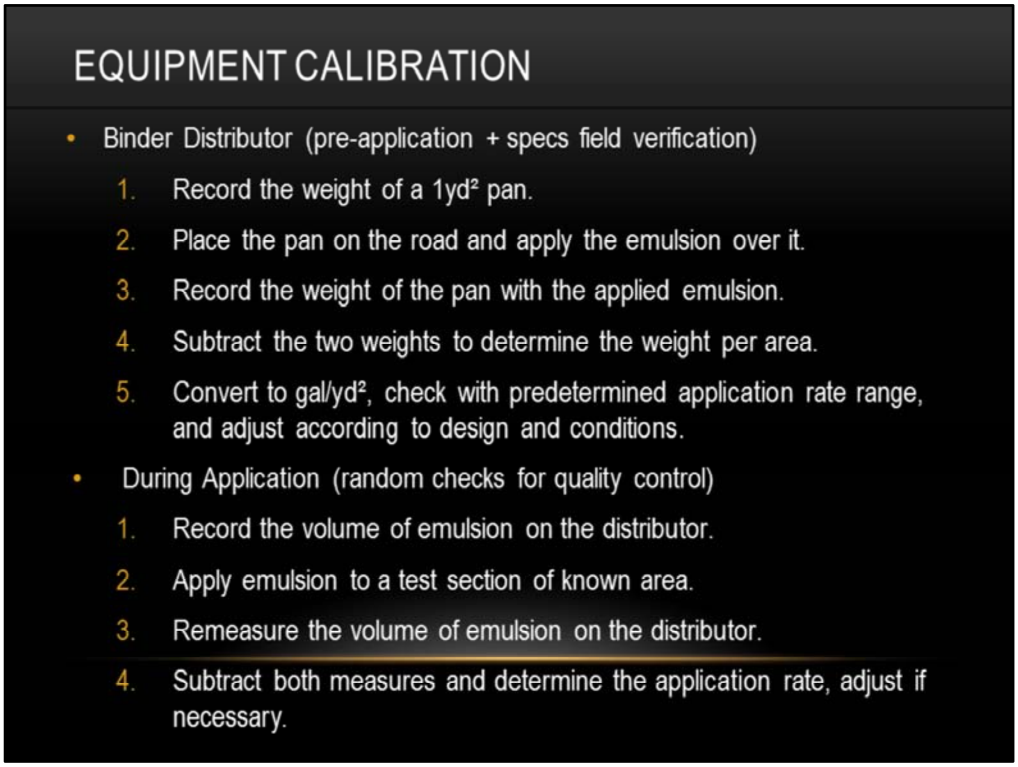
We want to use potable water, the use of contaminated or dirty water will cause the affect the mix. The manufacturer usually dilutes the emulsion and tests for water-emulsion compatibility.



If water in not compatible then it needs to be treated with an emulsifier solution. The manufacturer will probably provide more information and recommendations on this regard.



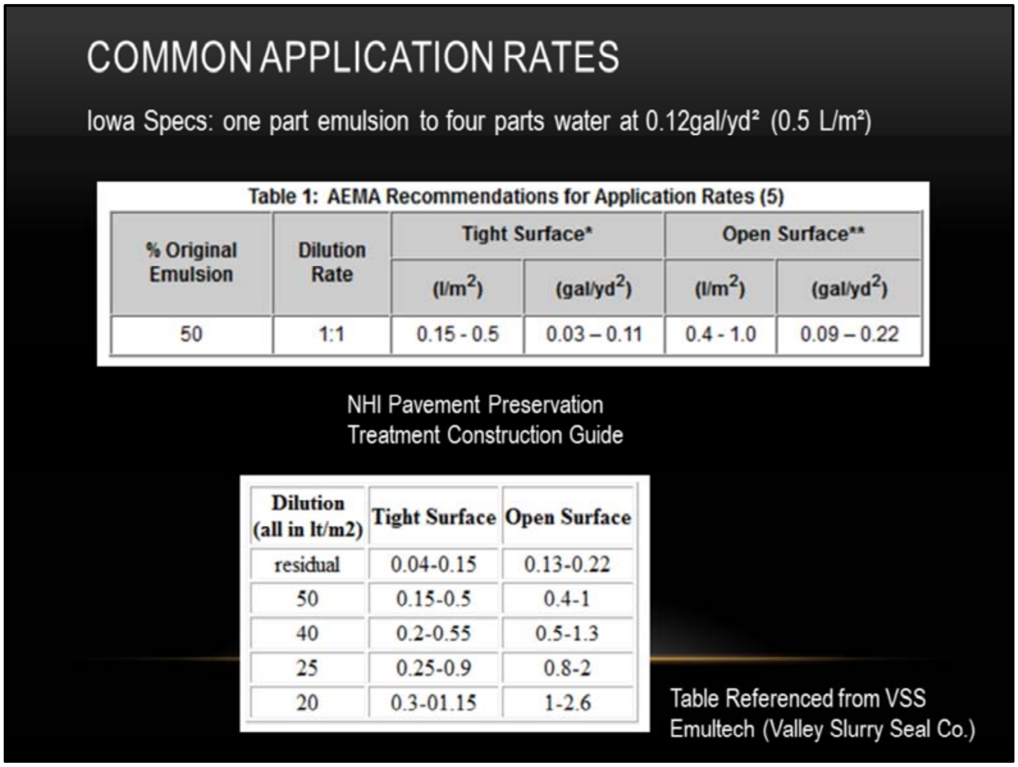
In order to achieve a uniform application, all the settings and features of the distributor need to be carefully checked before application.



Trial and error approach.

An equipment calibration during application, or recalibration, is highly recommended as we want to have the same application rate at all times. A little bit less can cause over-absorption, a little bit more can cause “bleeding”.

Some literature suggest calibrating and adjusting for application rates using the second options. That way you adjust the application rate according to the surface conditions and absorption.



COMMON APPLICATION RATES

Iowa Specs: one part emulsion to four parts water at 0.12gal/yd² (0.5 L/m²)

Table 1: AEMA Recommendations for Application Rates (5)

% Original Emulsion	Dilution Rate	Tight Surface*		Open Surface**	
		(l/m^2)	(gal/yd^2)	(l/m^2)	(gal/yd^2)
50	1:1	0.15 - 0.5	0.03 – 0.11	0.4 - 1.0	0.09 – 0.22

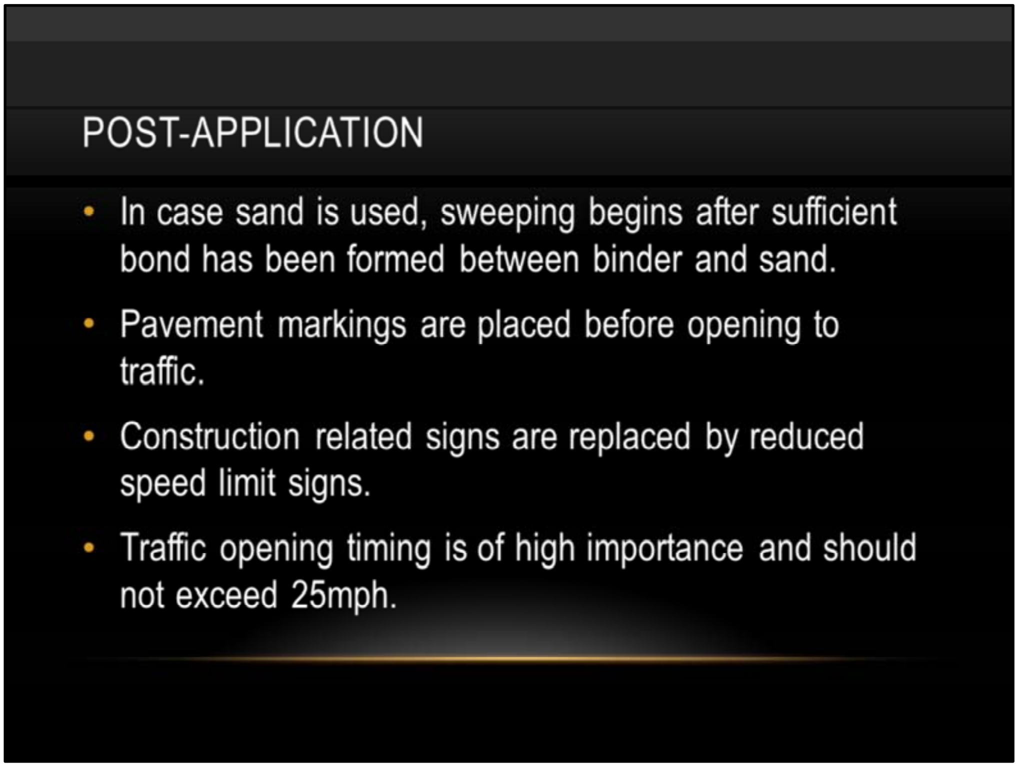
NHI Pavement Preservation
Treatment Construction Guide

Dilution (all in lt/m2)	Tight Surface	Open Surface
residual	0.04-0.15	0.13-0.22
50	0.15-0.5	0.4-1
40	0.2-0.55	0.5-1.3
25	0.25-0.9	0.8-2
20	0.3-01.15	1-2.6

Table Referenced from VSS
Emultech (Valley Slurry Seal Co.)

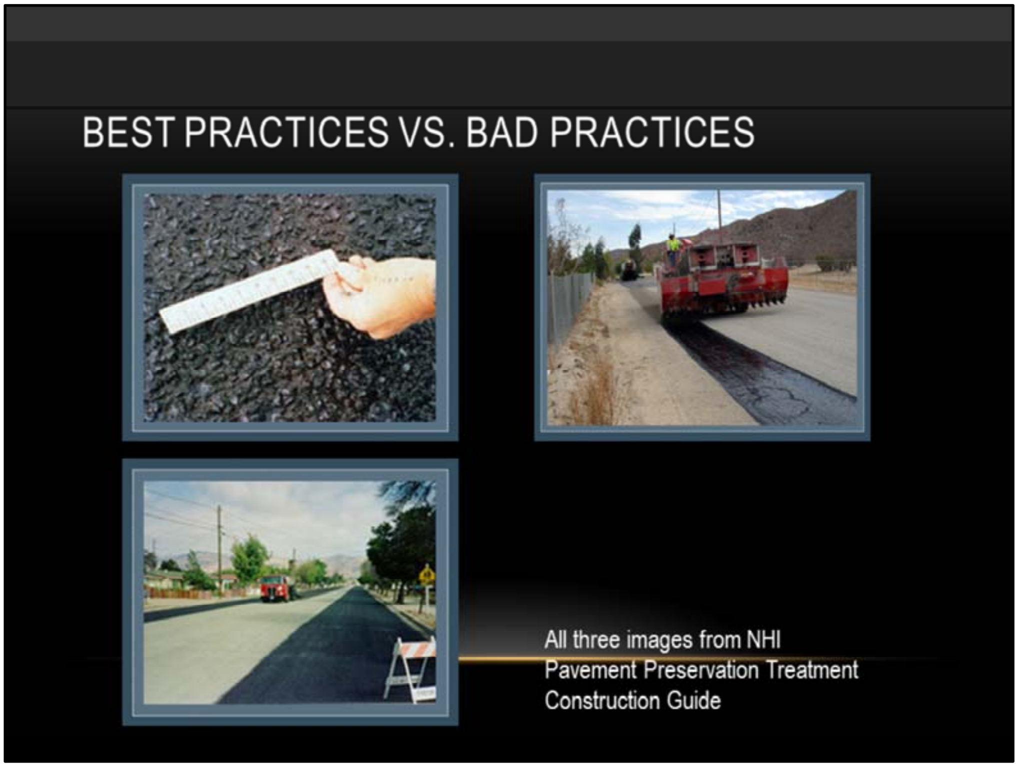
Tight surface: of low absorbance and relatively smooth
Open surface: relatively porous and absorbent with open voids.


DURING APPLICATION
Responsibilities of the inspector:
Application should look uniform
Application starts and stops on building paper.
Constant checks for plugged nozzles.
Constant checks for drilling and streaking.
Random application rate checks are made.
In case sand is used, no emulsion is on top of sand.
Enough trucks are on hand to keep a steady supply of sand, if used.



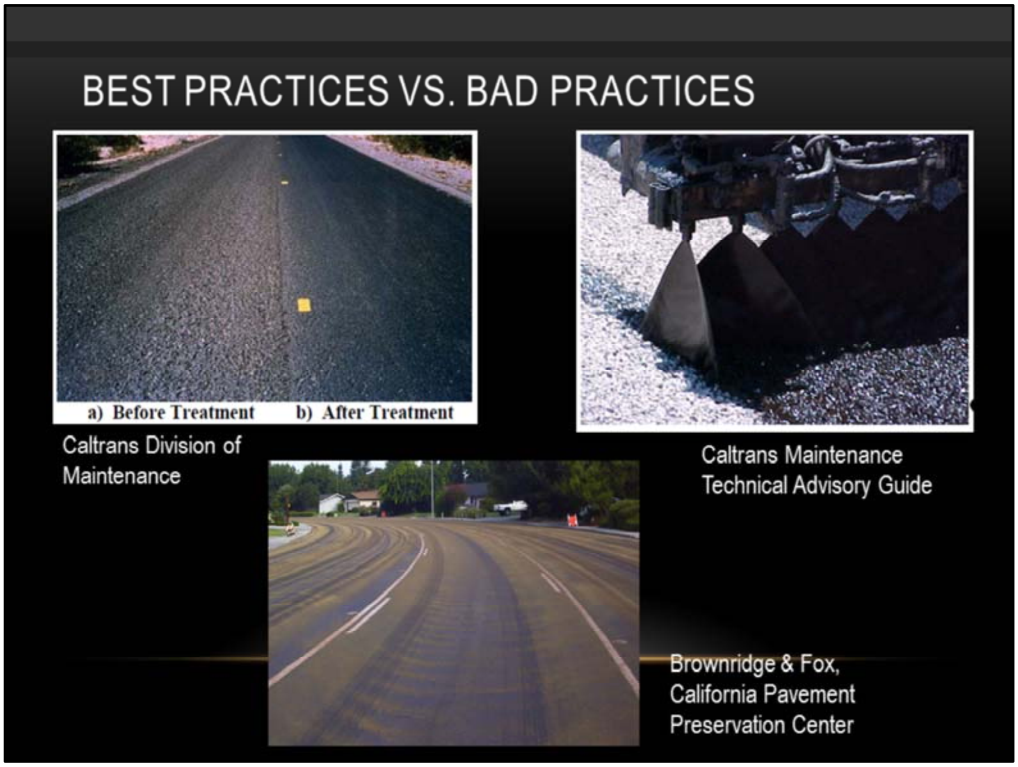
Unfortunately fog seals take their time to cure, so the timing of when the road is opened to traffic is critical. If opened too early, tires will tear up the seal.

At the beginning traffic speed should be controlled, but unlike seal coats, fog seals can be used in high speed roads.



First two images are examples of best practices, as a fog seal is properly applied after a seal coat in the top image and in the lower image the fog seal looks uniform over a road with no major distress.

Bad practice in this other image where major distresses, like the pothole in this case, were not addressed before applying the seal coat.

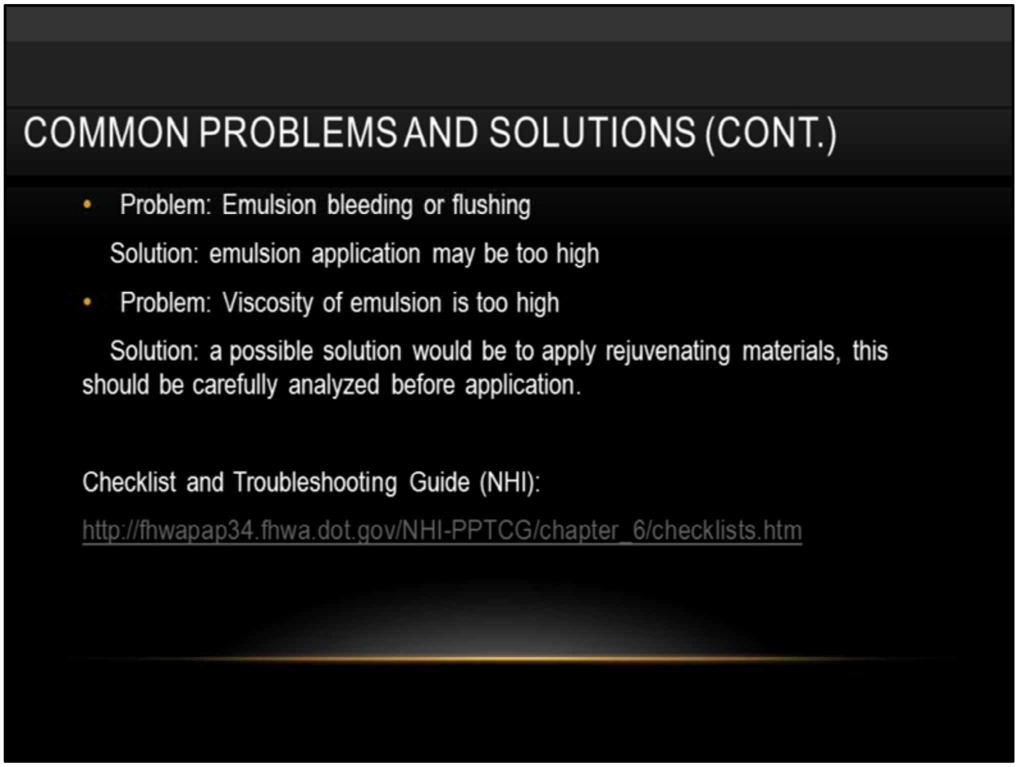


Again, good practice is the top image where after treatment is applied the appearance looks uniform with no signs of bleeding.

If sand will be used, the bottom pictures shows what the application should look like BEFORE sweeping.

Bad practice is not inspecting nozzle angles during application, this will cause application not to be uniform.

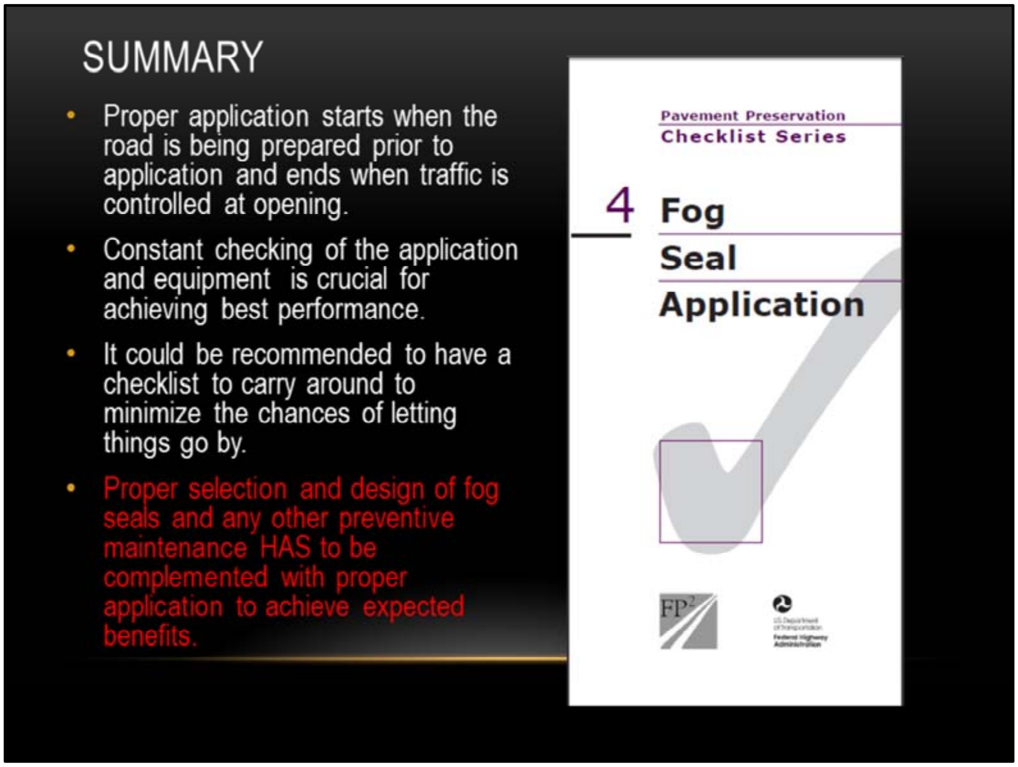
Some of this also apply to seal coats or any treatment that uses the same equipment.



This troubleshooting guide may come in handy, so it wouldn't be a bad idea to have a hard copy of it around during application.

DOS AND DON'TS
(CALTRANS DIVISION OF MAINTENANCE)

Do check water compatibility before dilution.
Do check dilution - has it been done, by whom, and when?
Do ensure that there is no contamination of the base emulsion by water, oils, or other liquids.
Do prevent contamination by other emulsions.
Do protect emulsions from freezing or localized boiling due to the application of direct heat.
Do heat emulsion gently and ensure heating coils are under the liquid level (max 50°C (122°F)).
Do load from the bottom of tankers or sprayers to avoid foaming.
Do check equipment and nozzles.
Do check application rates.
Do exercise proper traffic control.
Do ensure the know-how is available on the job.
Do add water to emulsion, not emulsion to water.
Don't store diluted emulsion longer than 24 hours.
Don't continuously stir or circulate emulsion.
Don't apply emulsion if air temperature is <10°C (50°F) and pavement temperature <15°C (59°F).
Don't apply emulsion if rain or cool temperatures are imminent.
Don't continue application if adequate breaking period is not available.
Don't open treated surface to traffic until coefficient of friction is at least 0.30 as determined by CT 342.



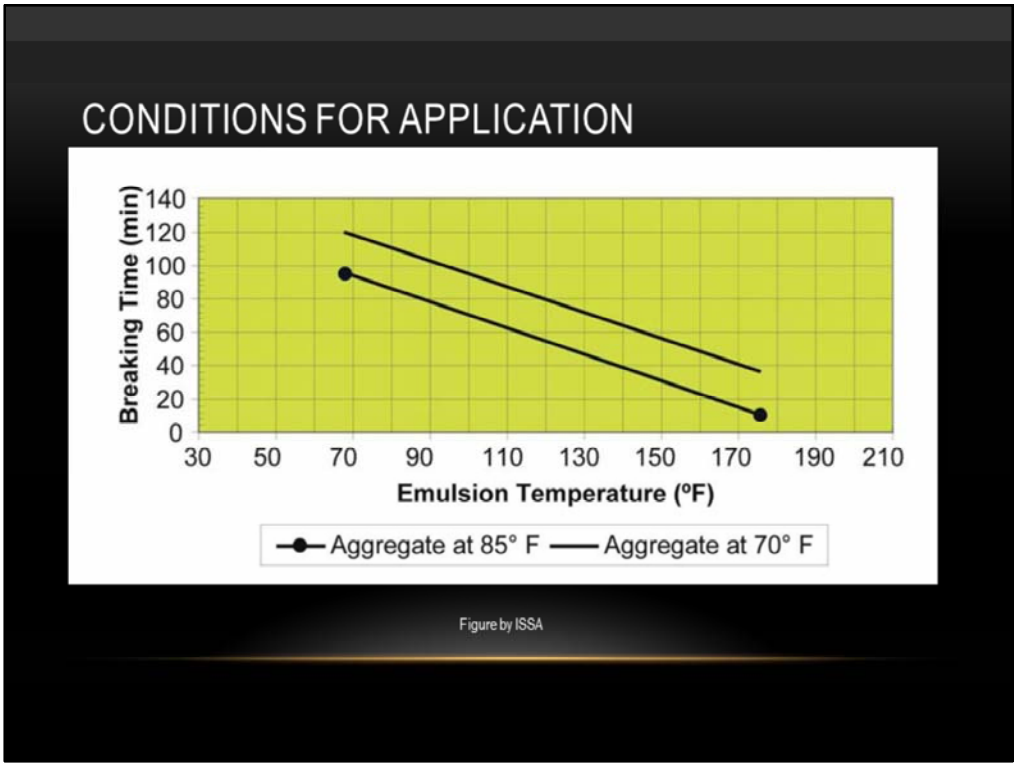
Application goes from getting prepared to traffic control after opening. If the road is not cleaned before applying the fog seal you will not achieve the benefits of fog sealing, the same thing happens if you don’t control traffic speed when opening the road.

The inspector has many responsibilities and it’s hard to keep an eye on everything.

PAVEMENT PRESERVATION: CONSTRUCTION – SLURRY SYSTEMS PART 1

Pre-Application

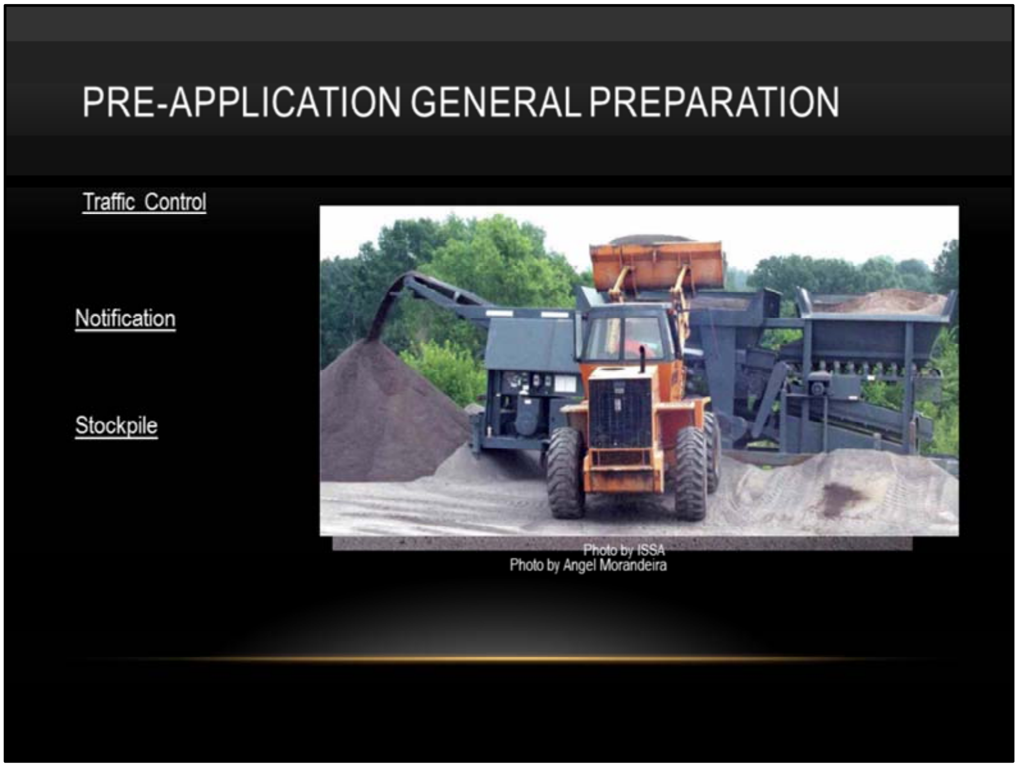
Why are proper pre-application Practices for Slurry Systems Important?



- Temperatures should be at around 50°F and rising. **If emulsions freeze the treatment will be ruined**
- Low temperatures = increased set times
- High temperatures = decreased set times
- Humidity should be 60% or less

- Neither Micro-surfacing or Slurry Seal should be placed if rain is eminent.

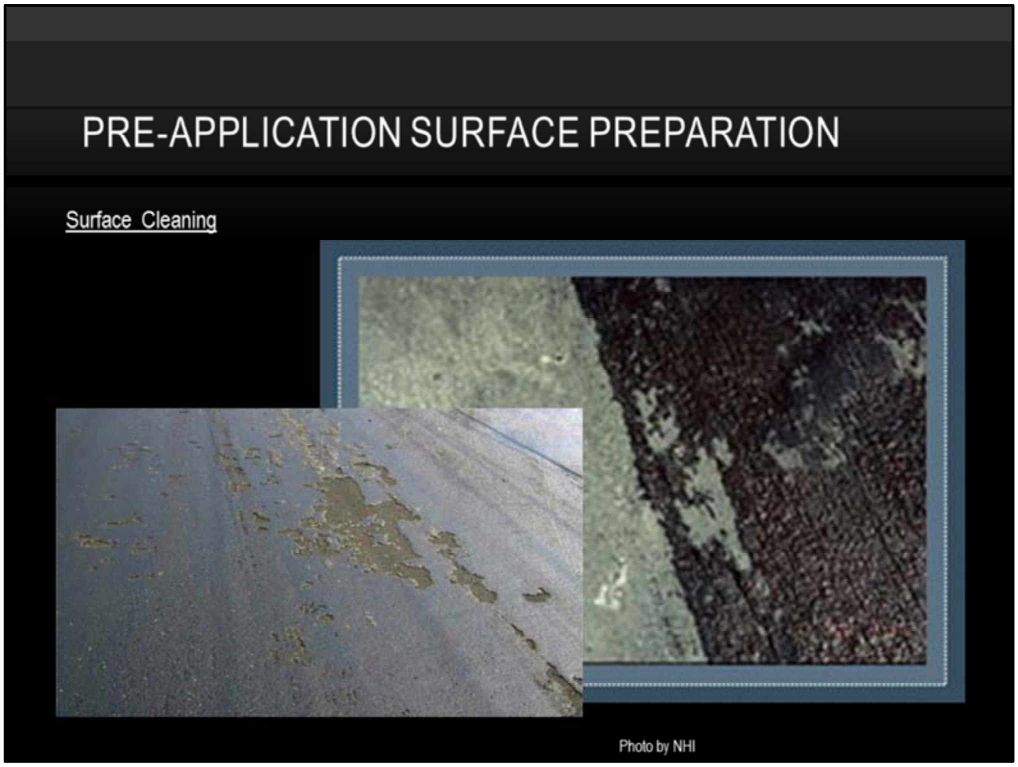
- Micro-surfacing can be placed at night but not slurry seal.



Traffic Control
- A traffic control plan should be well thought out before beginning application
- Layout of signs and barricades
- A sufficient amount of flaggers should be used to ensure safety
- Traffic Control is also needed to make sure the slurry system treatment has adequate time to cure

Notification
- The contractor should send out a written notification to all businesses and agencies within the project area.
- Although the contractor is responsible for this, make sure this is done because if the public is not properly notified it could cause problems.

Stockpile
- The contractor will need to set up a staging area for materials.
- Make sure the designated area is the closest as possible to cut down on shuttle time
- Take precaution that the area chosen does not threaten contamination of materials being used.

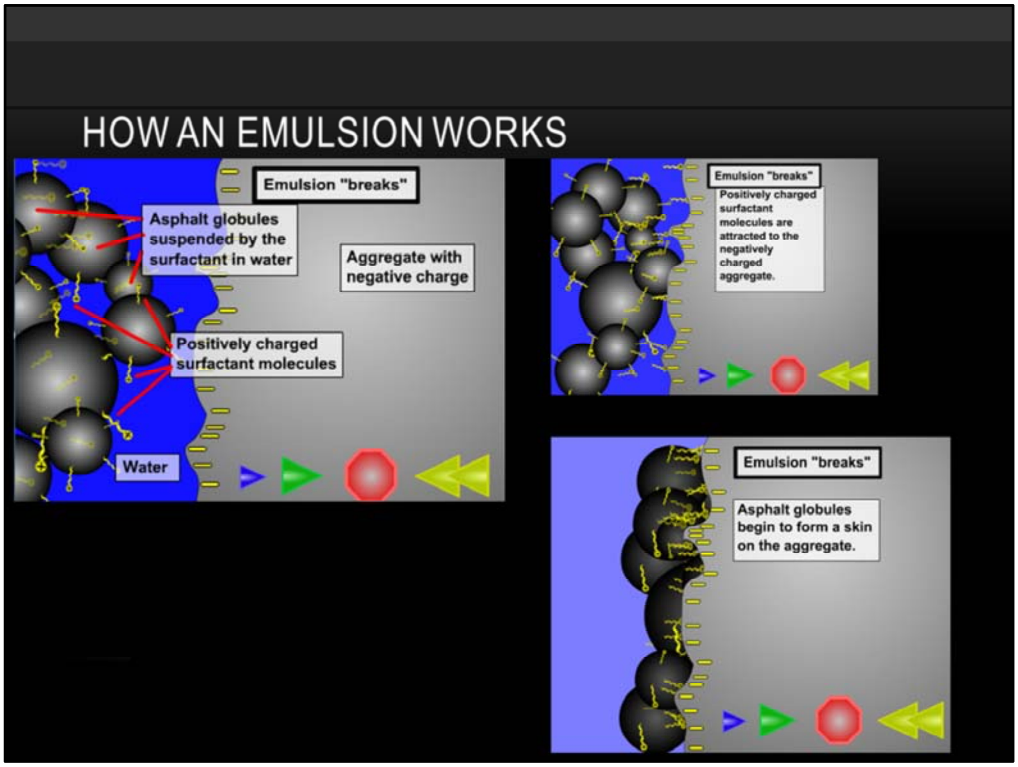


Surface Cleaning
- Prior to doing a slurry system treatment make sure required repairs have been done (crack fills, base failures, etc.)
- The surface should be thoroughly cleaned of all objectionable matter (vegetation, dirt, loose gravel, etc.)
- Vegetation can be killed off before hand with herbicides

- Grease/oil spots

- Slurry systems will not adhere to oil/grease spots on the surface so it must be cleaned with detergents before application

- The best way to clean the surface is using a mechanical broom. Using water to clean the surface can cause moisture to get trapped once the surface is sealed. (pg. 25)



When applying micro-surfacing, the emulsion being used will a cationic mixture. This means it is positively charged and will be attracted to negatively charged particles. You want the emulsion to adhere to the aggregate and the existing surface properly. Sometimes surfaces may look clean, but there may be dust left on the surface. In Iowa this could very well be clay or limestone dust, which is very negatively charged. This will cause the emulsion to be attracted to the dust and will adhere to it rather than the surface. This will cause areas to peal up and the application will no be successful.

*If the surface is not cleaned properly, the binder will not adhere to the existing surface properly and this will cause failures similar to those seen on the previous slides.

Pavement Markings

- Pavement markings need to be removed or protected to accommodate a slurry system treatment.

- There are 3 types of pavement markings: (pg. 26)

1) Paint Markings:
   - Most markings will not need treatment and the slurry system will bond properly. However, if the pavement is new it may be very smooth and here cold be a lot of paint build up. If this is the case then the paint should be removed.
2) Raised Markings:
   - These marking can be made of plastic, ceramic, or metal and have reflective devices on them. There are plastic protective covers out there but the spreader box tends to pull up the coverings. Raised marking should be completely removed and replaced.
3) Thermoplastic Markings:
   - Slurry Systems do not adhere to thermoplastic markings. It is not advised to try and cover the markings as it is labor intensive and presents other placement problems. Thermoplastic surfaces should be grinded down or removed completely for a slurry system treatment

Protection

- Utility structures and castings should be protected from a slurry system treatment (manhole covers, catch basins, valve boxes, etc.)
- Keep a sketch of locations so they are not lost during application.

- There are two ways to accomplish protection:

1) Cutting a paper cover to size and sticking it in place using a spray glue
2) Removing the casting covers, placing them into plastic bags, and then placing them back to there original position.

Scratch Coats
-Used on with Micro-surfacing to level pavements with transverse irregularities that are narrower than the width of the spreader box
-Can also be used for longitudinal ruts less than 0.5 inches deep
- A steel strike off is used to level the irregularities.
- Scratch coats should never be a stand alone treatment

Tack Coats
- Applied to pavements with a higher level of surface oxidation and is recommended on high traffic pavements.
-Should consist of part of emulsified asphalt and three parts water.
-Applied with a distributer at 0.10 to 0.15 GP/SY (rates are variable depending on many things)\
-Normally, tack coat is not required unless the surface to be covered is extremely dry and raveled or is concrete or brick. If required, the emulsified asphalt should be SS, CSS, or the micro surfacing emulsion. Consult with the micro surfacing emulsion supplier to determine dilution stability. The tack coat may consist of one part emulsified asphalt/three parts water and should be applied with a standard distributor. The distributor shall be capable of applying the dilution evenly at a rate of 0.05-0.15 gal/yd2 (0.23-0.68 l/m2). The tack coat shall be allowed to cure sufficiently before the application of micro surfacing. If a tack coat is to be required, it must be noted in the project plans.

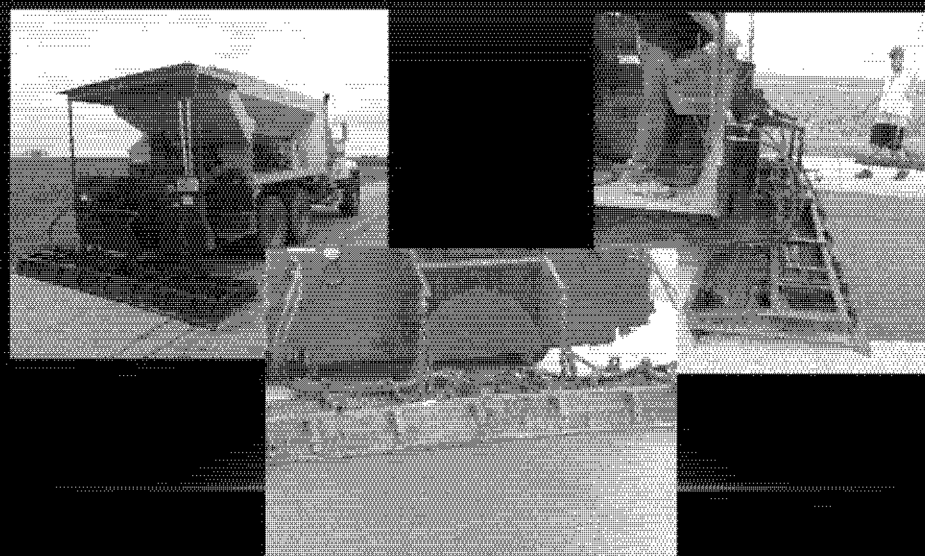
Pavement Pre-wetting
- Surface System Bonding
-Done through the spray bars of the placement machine.
-The rate of application of the fog spray should be adjusted to suit temperatures, textures, humidity, dryness, etc.
-The water used in pre-wetting should be applied such that the entire surface is damp with no apparent flowing water in front of the spreader box

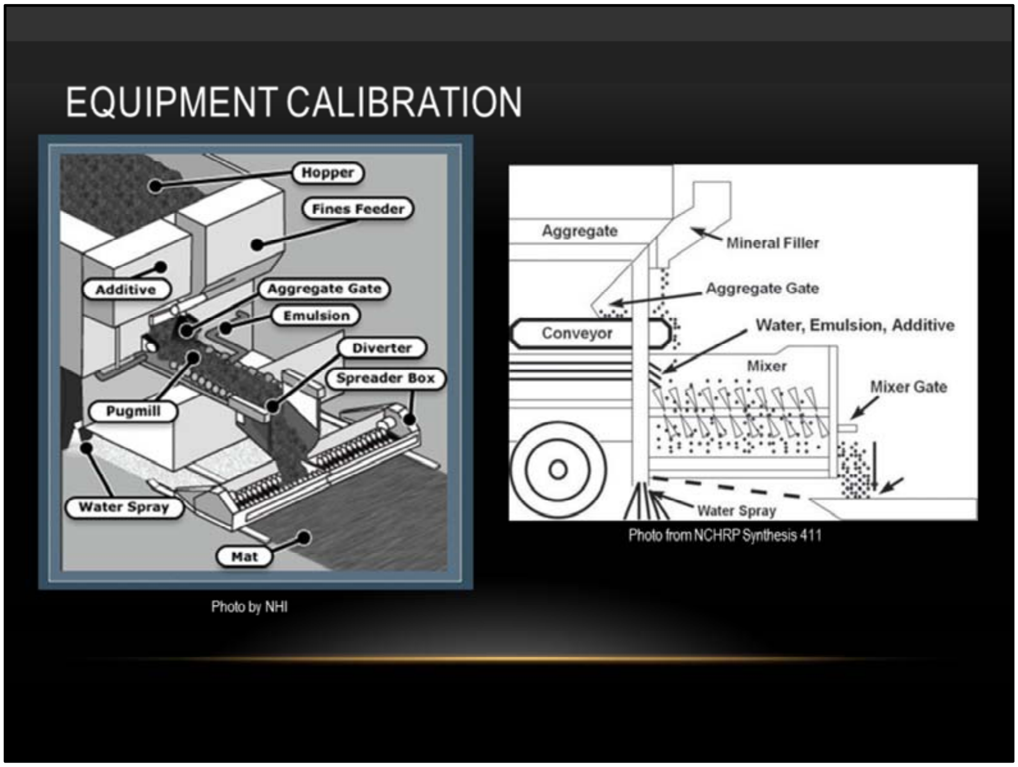
Test Strips
- Prior to starting treatment application, construct a minimum 300 ft test section to determine surface characteristics and set time. Engineer must approve before moving forward with application.

Spreader Box (pg. 30) & NHI (Different for micro and slurry)

Slurry Surfacing Machine
Spreader Box
Strike-offs
Rut Box
Hand Work Tools

EQUIPMENT – SLURRY SEAL





<u>Calibration Theory</u>
All mix designs and formulation are based on the combined weight of dry aggregate and dry mineral filler (if used). To set the placement machines to a given Job Mix Formula and produce a consistent material is critical.
Feed Rates of:

- Aggregate
- Mineral Filler
- Emulsified Asphalt
- Water
- Additive

<u>Inspectors Note:</u>
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.

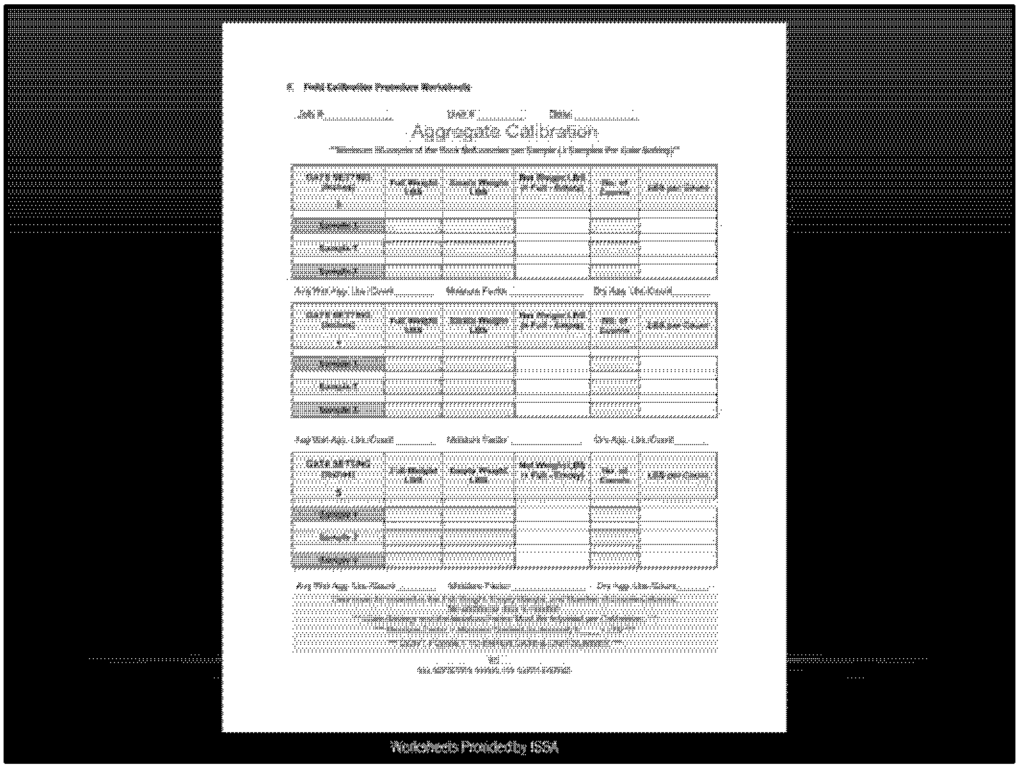
	Asphalt Emulsion Calibration Procedure for Positive Displacement Pumps
1	Connect the production emulsion pump output to a container
2	Run the pump long enough to fill the connection hose with emulsion to ensure all runs are the same
3	Zero the counter before each run
4	Pump a large enough sample of emulsion on each of three runs to ensure the accuracy will be 2% or better. The sameple size is calculated by dividing the accuracy of the scale by 0.02. *For Example, if wieghing the emulsion sample in a barrel on a platform scale with an accurac of ± 1 pound, the minimum sample needs to be 50 pounds (1 lb/0.02).* Determine the net weight for each run by weighing either the placement machine (on a truck scale) before and after the run or weighing the emulsion pumped (on a platfrom scale). Divide the net weight pumped by the number of counts of the rock/aggregate belt for the three test samples and record the pounds per count for each
5	Average the pounds per count of the three runs
6	The placement machine should deliver such volumetric consistency that the deviation for any individual emulsion run shall not exceed 2% of the mathematical average of three runs
7	The average pounds per count results will be used in the gate setting calculations

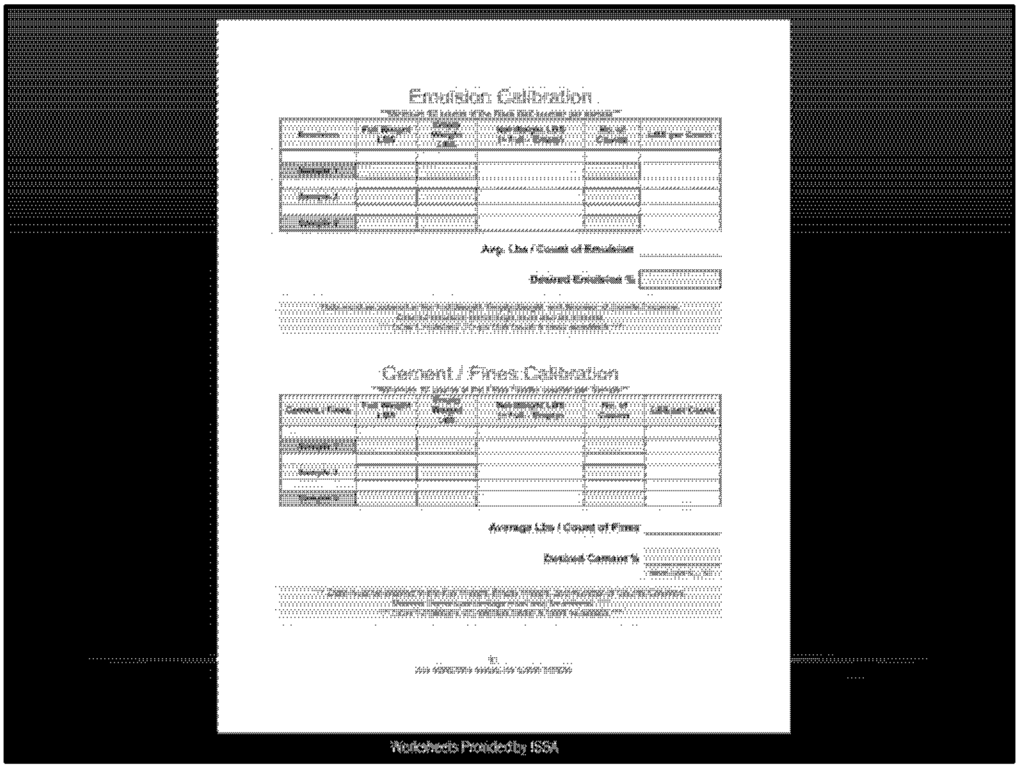
*Tables provided by ISSA

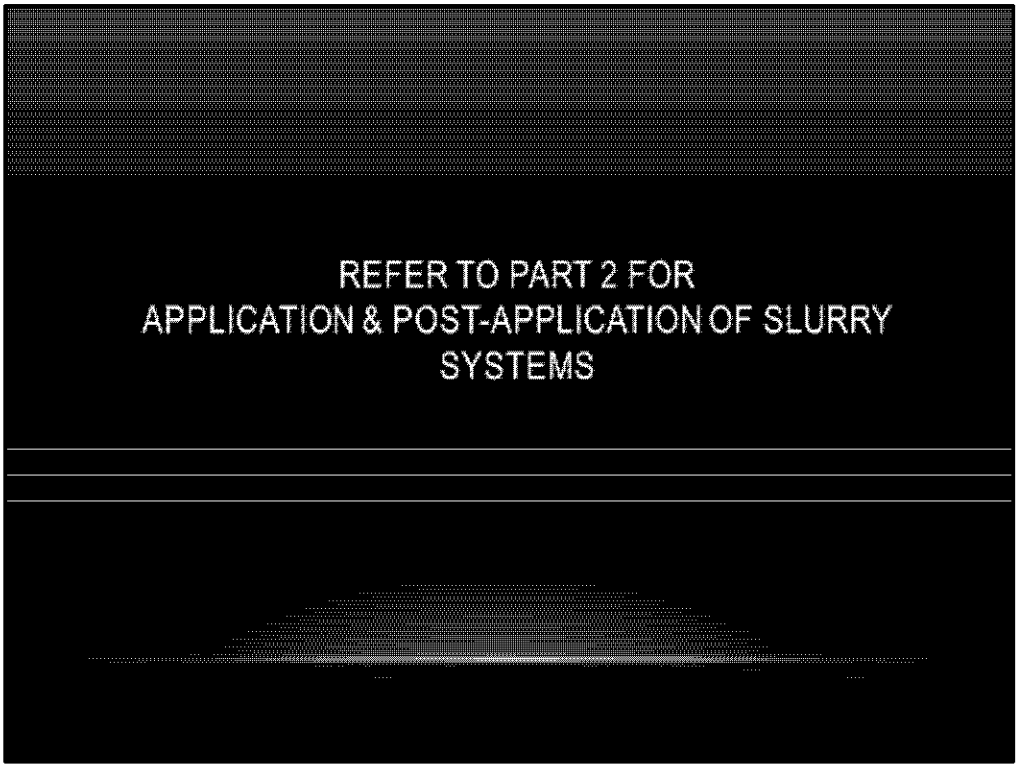
	Asphalt Emulsion Calibration Procedure for Variable Displacement Pumps
1	Set the emulsion pump to the factory recommended setting and lock in place.
2	Follow the positive displacement pump procedure
3	If the gate setting for the aggregate for the Job Mix Formula is unusually high, decrease the emulsion pump volume setting and perform the emulsion calibration and gate setting calculation again
4	If the gate setting for the aggregate for the Job Mix Formula is unusually low, increase the emulsion pump volume setting and perform the emulsion calibration and gate setting calculation again

Dry Additive/Mineral Filler Calibration Procedure	
1	Run the mineral filler auger long enough to ensure the auger is full of material
2	Use a small pan or container to catch the mineral filler from the delivery auger before it is deposited in the mixer
3	Zero the counter before each run
4	Deliver a large enough sample of mineral filler on each of three runs to enusre the accuracy will be 2% or better. The sample size is calculated by dividing the accuracy of the scale by 0.02. For Example, if wieghing the emulsion sample in a barrel on a platform scale with an accurac of ± 1 pound, the minimum sample needs to be 50 pounds (1 lb/0.02). Determine the net weight for each run by weighing the mineral filler delivered. Divide the net weight delivered by the number of counts for the three test samples and record the pounds per count for each.
5	Average the pounds per count of the three runs
6	The placement machine should deliver such volumetric consistency that the deviation for any indidvidual mineral filler run shall not exceed 2% of the mathematical average of three runs
7	Follow the procedure provided by the equipment manufacturer to set the mineral filler auger rate

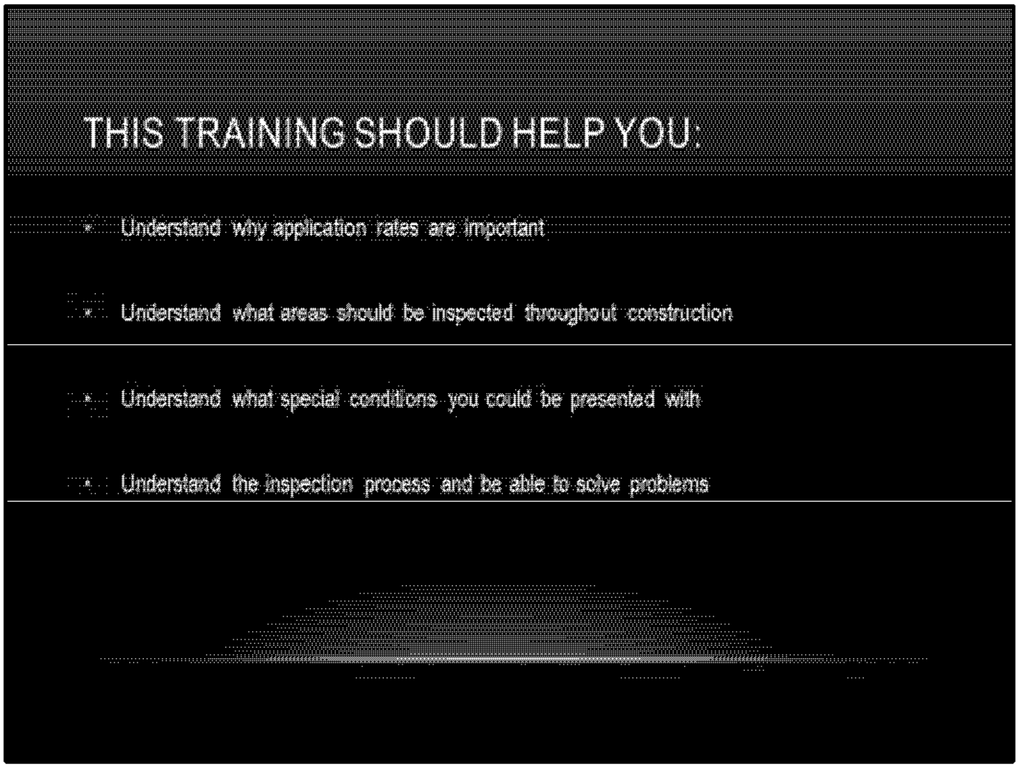
Table provided by ISSA


Aggregate Calibration
Worksheets Provided by ISSA

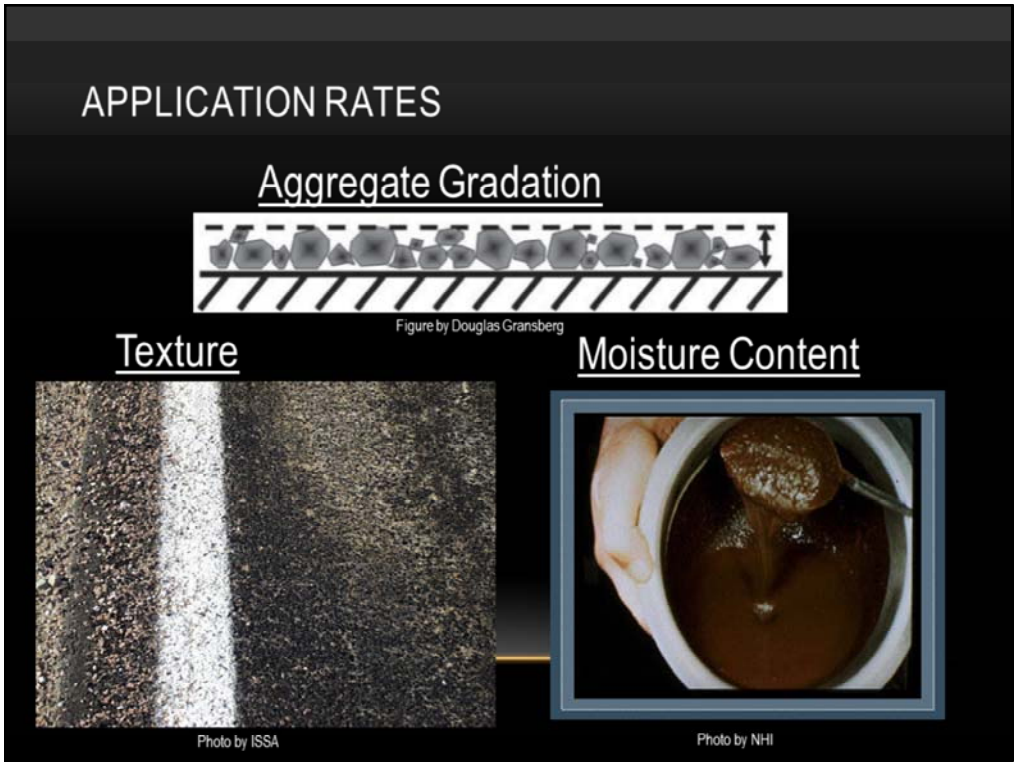

Emulsion Calibration
Cement / Fines Calibration
Worksheets Provided by ISSA


REFER TO PART 2 FOR
APPLICATION & POST-APPLICATION OF SLURRY
SYSTEMS

The information used from the ISSA and NHI


THIS TRAINING SHOULD HELP YOU:
Understand why application rates are important
Understand what areas should be inspected throughout construction
Understand what special conditions you could be presented with
Understand the inspection process and be able to solve problems

Full Width
Scratch Coat
Rut Filling
Patching



Application Rates
- An advantage of slurry systems is the ability to adjust the application rates throughout the project. The correct/incorrect application rate can have a huge effect on the success of a project
- Excessive thickness results in rippling, displacement, and segregation.
- Inadequate thickness can cause raveling and reduced life.
- Iowa DOT specification requires at least 20 lbs/SY for microsurfacing and

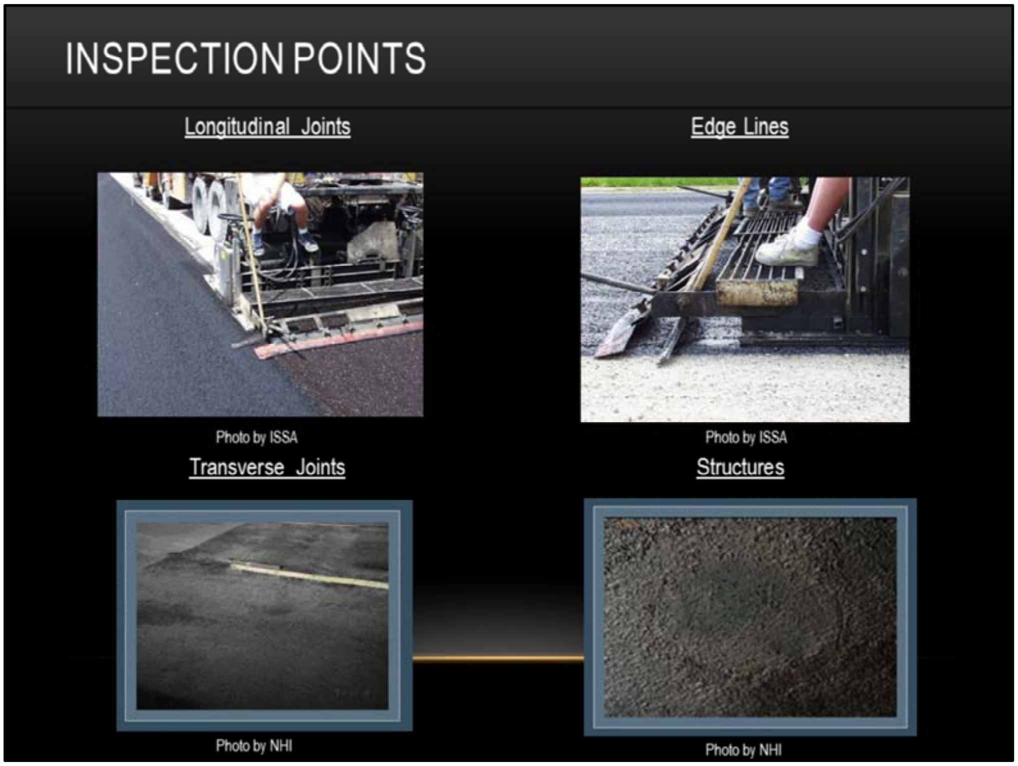
1. Aggregate Gradation
- Aggregates may be within specification but they may either be on the coarse side (greater percentage are larger sizes) or finer (greater percentage are smaller sizes).
- Coarser aggregates need to be applied thicker otherwise large aggregates will get caught and streak.
- Finer aggregates must be applied thinner
- Slurry Seals are designed to be placed one stone thick so placing thinner, thicker, or multiple layers to increase thickness will create an unstable seal and may lead to failures.
- Micro-surfacing uses multi-stone depths, the goal for micro-surfacing is to place the material 1.5X the aggregate in mixture

2. Existing Surface Texture
- The existing surface texture (void content) directly affects the application rate of a slurry system
- The more porous the surface the more material needs to be placed

3. Moisture Content
- The consistency of a slurry system can be compared to fresh Portland cement.
- If mixture is too wet the emulsion will flow out of the mixture causing the large aggregates to fall to the bottom and the fines to float to the top. The surface will be very black and shiny.
- If too dry, the materials won’t mix correctly and dry mixtures often result in pre-mature breaking or setting while still in the spreader box.
- The tendency is to add too much water because it increases workability.
- A good test is to draw a line with a stick and if the line fills with fluid, the mixture is too wet.

Factors Influencing Application Rates	
1	Adherance to the job mix formula (JMF) aggregate gradations is critical. Often the designated aggregate gradations may vary in particle size distribution. For example, a Type II aggregate from one supplier may be finer than a Type II aggregate from another supplier and thus, could easily be applied lighter. Aggregate produced by different types of crushers from the same parent rock may producedifferent shaped particles. For instance an imapct crusher will produce nugget shaped particles while a cone crusher will produce flat and elongated slivers.
2	Aggregates may vary in unit weight and a thicker application of one rock may actually weigh less than a thinner application of antoher. It is important to recalibrate the placement machine(s) for changes in aggregate sources.
3	Surface texture will affect the application rate. A smooth surface does not have as many voids to fill and thus keeps the spread rate at a minimum. A weathered, raveled, open surface will increase the spread rate as the material fills the voids at the same time it is covering the surface.
4	Surface textures will often vary on the same road between traffic areas and shoulders or centerline areas. Application rates will vary with surface texture and thus, may vary across any given cross section of a pavement.

Table by ISSA

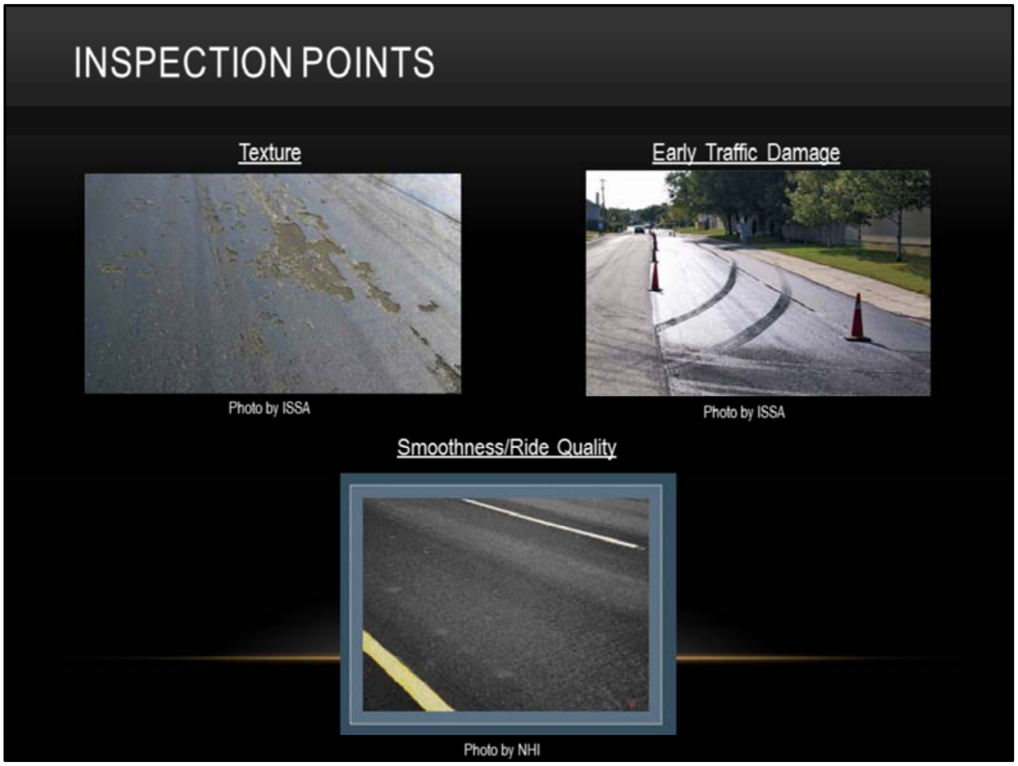


<u>Longitudinal Joints</u>
- Should be straight and uniform
- Follow traffic lane on curve sections
- If an overlapped the lap should not exceed 3 inches

<u>Edge Lines</u>
- Should follow existing pavement edge line
- If operator is having trouble a string line should be used
- If the mixture is too liquid and is running off the edge onto the shoulder, the operator should be stopped until the mixture is at a proper consistency

<u>Transverse Joints</u>
- Inevitable with truck mounted placement machines
- Joints are always butted so that a bump doesn't form (keep handwork to a minimum)
- Start Joints on roofing felt to help with problems

<u>Structures</u>
- The elevation of structures such as manholes and drainage gratings need to be adjusted and the structures need to be protected

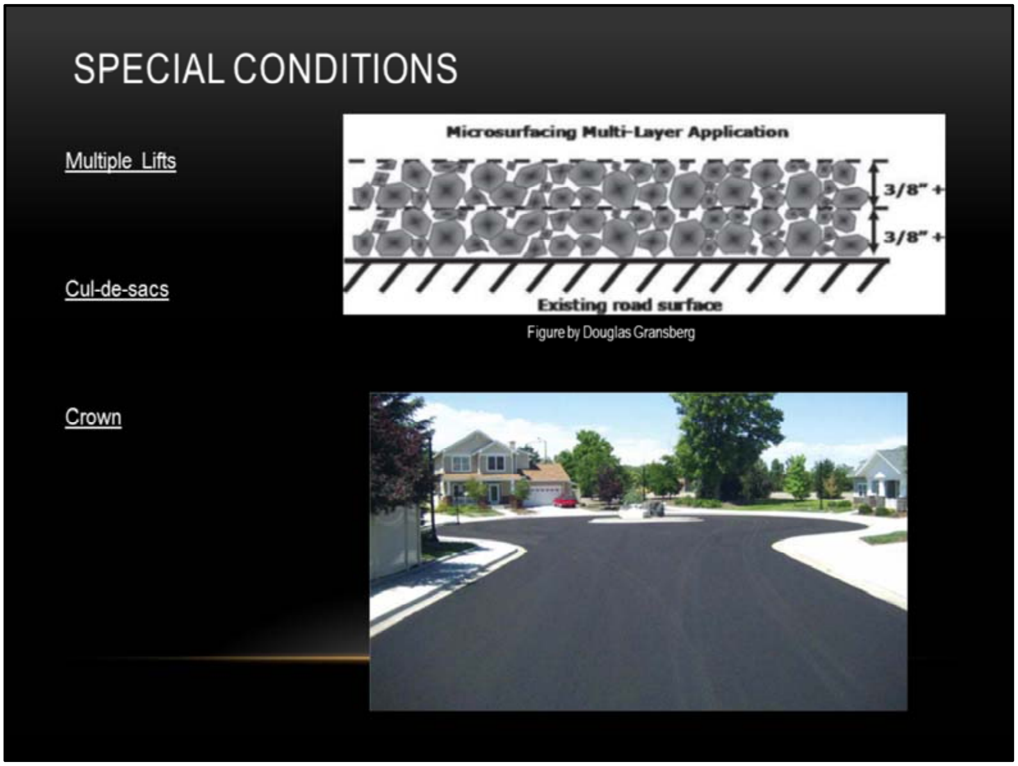


Texture
- If the calibrate process is done correctly this will not be a problem
- Major texture failure is known as a "false slurry" where emulsion breaks into fine material and debonding occurs

Early Traffic Damage
- Premature opening to traffic can cause early failure and raveling
- A good rule of thumb for slurry seals is that the material is ready to carry traffic when it has turned black
- A general rule of thumb for micro surfacing is that is can carry traffic when it is expelling clear water

Smoothness/Ride Quality
- Slurry seals do not have the ability to improve ride quality as they follow the same contours as the existing road.
- Micro-surfacing has the ability to improve the ride quality and using rollers while it cures can increase the effectiveness
- If a stiffer mix is being used, the spreader, if incorrectly set up, may chatter and bump as the material is being placed and may cause what is called a "washboard effect".

Yield Checks
- Comparing the area covered to the material placed
- At least 4 yield checks/day are recommended

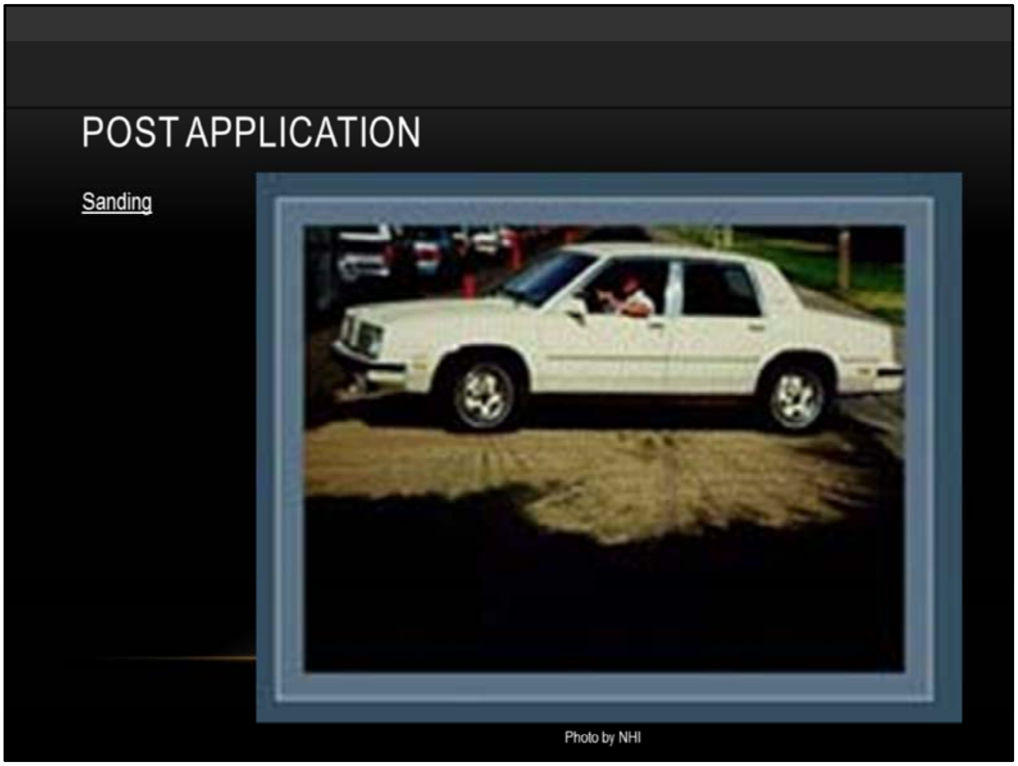


Multiple Lifts
- Being sure to check the application rates required for a multiple lift micro-surfacing

Cul-De-Sacs
- More time should be allowed for cul-de-sacs to cure because of a higher stress area

High Quarter Crown
- Insure the quarter crown is fully covered.
- Allow the spreader box to flex and use a flexible rear strike-off

There are also other special conditions. Others can be found in the ISSA inspectors manual.

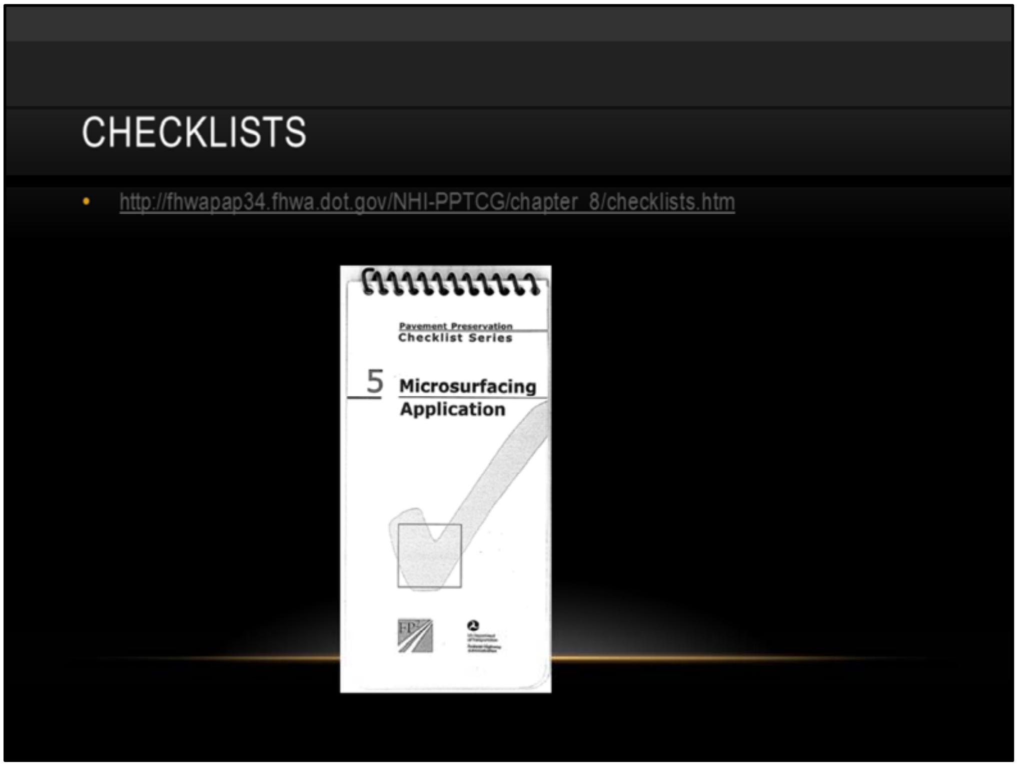


Usually slurry systems do not need much for post application, but in some cases getting traffic back on the surface is a necessity. If this is the case, sanding the surface can help with pealing and tracking.

INSPECTORS EQUIPMENT

Suggested Basic Equipment

- Calculator
- Measuring Wheel
- Surface Temperature Measuring Device
- Camera
- Shovel
- Sampling Containers



The top link is to a checklist that can be found on the NHI website. The other checklist shown can be obtained through FP2.

TROUBLE SHOOTING - SLURRY

Problem	Cause	Prevention
Non-uniform Surface	Different Machine Mixing Proportions - Variations can be caused by the materials used:	Proper Calibration of all placement machines can help mitigate these issues.
	1. Cement can cause a dull black, grey or ashen surface (rain on fresh slurry may turn the surface grey also). The color will go away with traffic.	
	2. Aluminum sulfate tends to promote a dark black color and show outlines of stains. The higher mineral content in water will accentuate the non-uniform appearance. These disappear with time	
	4. Additives may leave a surface sheen, but this will disappear with time.	
	5. If water is used excessively it can case the asphalt to float and will yeild a slick black appearance. If water is accidently sprayed onto the slurry, it will wash the emulsion off leaving the color of the aggregate.	

Problem	Slurry Seal Cause	Prevention
Raveling	1. Aggregate lacks sufficient embedment due to insufficient asphalt content.	Adherance to the job mix formula, ambient conditions, proper application rates, and sufficient time until opened to traffic.
	2. Poor quality aggregates used	
	3. Application rate was too thin	
	4. Matrix has a lack of fines to fill voids between large aggregates	
	5. Treatment was placed in cooler temps	
	6. Premature opening to traffic	
	7. Treatment was rained on prior to proper curing	

Problem	Slurry Seal Cause	Prevention
Bleeding or "Fat Spots"	1. Mixture contains too much water or asphalt emulsion	Proper machine calibration and minimizing overlaps. Also sufficient cure time and proper mateial for crack treatments
	2. Heavy overlapping of passes	
	3. Slurry is incompatible with pretreated crack filler or sealer.	
	4. Prior crack treatment had not fully cured before application	

Problem	Slurry Seal Cause	Prevention
Blotching at beginning and end of passes	1. Some older machines require each mix component to be engaged by the operator and this can cause them to be started improperly.	New machines automatically proportion and sequence material.
	2. Starting water too early	
	3. Starting the emulsion too early	

Problem	Slurry Seal Cause	Prevention
Breaking too fast	1. High temperatures in either the emulsion or the road surface.	A skilled operator can apply hot mixtures successfully by adding water and additives, but another option is to let the emulsion cool before placing
	2. Normally emulsions are delivered to jobsite at an elevated temperature to promote set, but on very hot summer days this can cause problems	

Problem	Slurry Seal Cause	Prevention
Breaking too slow	1. Treatment is placed at temperatures below recommended range and/or higher humidity.	Suspend operation if conditions are not recommended. If placing in shaded areas, palce early in the day to give time to cure
	2. In early spring and late fall, slurry treatments applied in shaded areas may have prolonged curing times	

The ISSA inspectors manual.

TROUBLE SHOOTING - SLURRY

Problem	Slurry Seal Cause	Prevention
Poor handwork results	1. High temperatures (accelerated breaking times and less working time for handwork)	Place handwork areas earlier in the day and in cooler temperatures. Lay material in small amounts at a time. If portions of the material break too soon, remove and replace.
	2. Insufficient amount of workers to spread and finish material before it breaks	

Problem	Slurry Seal Cause	Prevention
Tire marks and surface abrasion	1. Vehicle power steering	Use a hard base asphalt, specify polymerized emulsion, use a rubber-tired roller, apply treatments in cooler months of the year and allow treatment to cool before trafficking, and broadcast sand over treatment
	2. [illegible]	
	3. Stationary vehicle steering (parking lots)	
	4. The bond between the material and existing surface has a lower friction than the tire and the material	

Problem	Slurry Seal Cause	Prevention
Adherence to crack sealants and fillers	1. Flexible materials (such as rubber based) sealants will not bond well.	Obtain the crack treatment material product data (properties, expected performance). Avoid overfilling cracks with sealant and filler. Allow sufficient cure time for the crack treatment.
	2. The overbanding technique will cause the spreader to track more material and push it during application.	
	3. If a crack treatment has been cured and covered with a tack coat, the material can adhere to spreader machine tires and dislodge the crack material.	

Problem	Slurry Seal Cause	Prevention
Bond with existing pavement	1. Seal coats containing coal tar have poor adhesion and will probably fail	Extensive cleaning of possible problem areas. Acrylic sealers can be used in severe cases. Grinding down the existing surface to a course surface.
	2. Sand seals adversely affect slurry seal bonding capabilities.	
	3. Materials with sulfates, free aggregates, hydraulic oil, diesel, etc. also causes problems.	
	4. Animal remains contribute fatty oils that will debond slurry.	

Problem	Slurry Seal Cause	Prevention
Rain on fresh slurry seal	1. Inattentive eye	If light rain happens to fall, close the road until surface is dry. If moderate rainfall occurs it will generally wash the emulsion off the top.
	2. Unexpected isolated rain events	Close traffic and allow treatment to dry. Then sweep off loose aggregate. If heavy rain occurs the slurry will need to be replaced.

TROUBLE SHOOTING - SLURRY

Slurry Seal		
Problem	Cause	Prevention
False Break	1. Rapid water evaporation due to high heat and low humidity	Work earlier in the day and/or pre-wet the pavment surface.
Slurry Seal		
Problem	Cause	Prevention
False Slurry	1. Extensive binding of asphalt on the fine aggregate during the mixing process.	Calibration of placement machines and confirm compliance with job mix formula
Slurry Seal		
Problem	Cause	Prevention
Grade Flow	1. Machines that are not equiped with an auger distribution system will allow slurry to flow laterally on crowns and superelevated curves.	A skilled operator can correct this issue by applying more slurry when going uphill and apply more pressure to the rubber strikeoff. If going downhill use a stiffer mix. Best prevention is to use a spreader with an auger.

TROUBLE SHOOTING - MICRO

Microsurfacing		
Problem	Cause	Prevention
Poor longitudinal joints	1. The placement machine may not have driving controls on both sides of machine. 2. Poor planning of application by contractor.	Specs should require driving controls on both sides. Be sure the contractor is planning to correctly place longitudinal lines.
Microsurfacing		
Problem	Cause	Prevention
Poor transverse joints	1. Transverse joints were constructed without using roofing felt, metal strips, or other start/stopping methods. 2. The spreader box was run until empty (poor planning by contractor). 3. The mixture may not be performing as designed due to environmental conditions.	Minimize number of joints required on the project. Be sure the mixture and spreader box are correctly matched for the project.
Microsurfacing		
Problem	Cause	Prevention
Longitudinal joints are overlapped and retain water	1. Due to poor contractor/operator application and planning.	Overlaps, when needed, should not exceed 3 inches. If overlaps are not needed, use butt joints.
Microsurfacing		
Problem	Cause	Prevention
Non-uniform, poor [illegible]	1. Rapid break of mixture.	The mixture should contain an additive to increase workability.

TROUBLE SHOOTING - MICRO

	Microsurfacing	
Problem	Cause	Prevention
Debonding	1. Vegetation, animal carcasses, loose aggregate, soil, petroleum, and excessive water on existing surface. 2. Snow plows	Thorough cleaning of the existing surface.
	Microsurfacing	
Problem	Cause	Prevention
Mixture breaks before even applied (cold-mix)	1. The mineral filler used has caused the mixture to break too fast. 2. The environmental conditions (along with the mineral filler) has caused the mixture to break too fast. 3. Change in water supply	Make sure the mixture is constantly in movement (augers). Use additives to control the break throughout the changes in environmental conditions.
	Microsurfacing	
Problem	Cause	Prevention
Poor surface texture	1. Oversized aggregate 2. Open surfaces in the existing pavement 3. Built up mixture in the spreader box	Clean the spreader box between each use. Use a scalping screen to catch oversized aggregates. Repair existing surfaces if needed to avoid problems due to its texture.

PAVEMENT PRESERVATION: CONSTRUCTION – CRACK FILL/SEAL


IMPORTANCE OF CRACK FILL/SEAL CONSTRUCTION TRAINING
The training should help you
Understand the best application conditions
Understand the best application procedure
Be able to spot bad practices
Identify tools to properly execute a project

CONDITIONS FOR APPLICATION

Conditions for Application	
Factor	Recommendation
Time of Year	Spring or Fall
Weather	Do not apply if rain or freezing is expected
Temperature	This varies with materials, but ambient and surface temperatures need to meet the manufacturer and agency requirements
Existing Surface	Surface must be completely dry and free of all objectionable matter

- Winter time is ideal because the crack is at its largest, but realistically the best time is during spring or fall

- It is a bad idea to apply if impending rain or freezing weather is expected

- Ambient and/or surface temperature need to meet the manufacturer and agency requirements

- Surface must be completely dry and free of other pavement distresses than cracks and there can be no moisture present on the surface

<u>Crack Cutting Equipment</u>
- Router/cutter configuration is adjusted to the required width and depth
- Make sure cutting equipment doesn't have rounded, chipped, missing, or broken teeth.

<u>Cleaning Equipment</u>
- Make sure air compressors have required pressure and volume
- Make sure hot air blasters/heat lancers are functioning correctly, if these are not it can be bad for the project.

<u>Hot Applied Sealants:</u>
- Check the melter heating, agitation, pumping systems, valves, and thermostats to ensure they are working correctly
- Make sure melter heating system is thermostatically controlled
- Make sure temperature gauges are calibrated and tested for accuracy
- Make sure proper wand tips are used

<u>Other Application Types:</u>
- Pumps for cold applied are functioning correctly
- Pour pots are in good working order
- Shaping and forming tools are clean and in good condition

<u>Finishing Equipment</u>

Crack Cutting is only done when the crack will be sealed.

TRAFFIC CONTROL AND SAFETY

- Refer to the specifications to make sure:
  - - Signs and devices meet the requirements
  - - The overall set up is compliant
  - - Traffic is not opened too soon
- Signs should be removed or covered when they are no longer needed
- Operators of equipment should have proper PPE.

Cutting is done for Crack Sealing only

Cutting can be done with either a rotary impact router or a diamond blade

Diamond blades are used to keep edges smooth, but router blades are more maneuverable

Uniform, rectangular reservoir centered over a crack

Correct width and depth should be checked

The asphalt and concrete condition should be checked to make sure it can withstand the cut without spalling

Purpose: Eliminate debris and contamination

Many crack sealing failures are due to dirty crack walls

Can be done by hand tools, brushing or sweeping, airblasting, hot airblasting, or sandblasting.

<u>Manual Methods</u>

- If done correctly can be as effective as other means, but it is very time consuming

<u>High-Pressure Airblasting</u>

- Good to remove particles, but not for drying cracks

<u>Water Blasting</u>

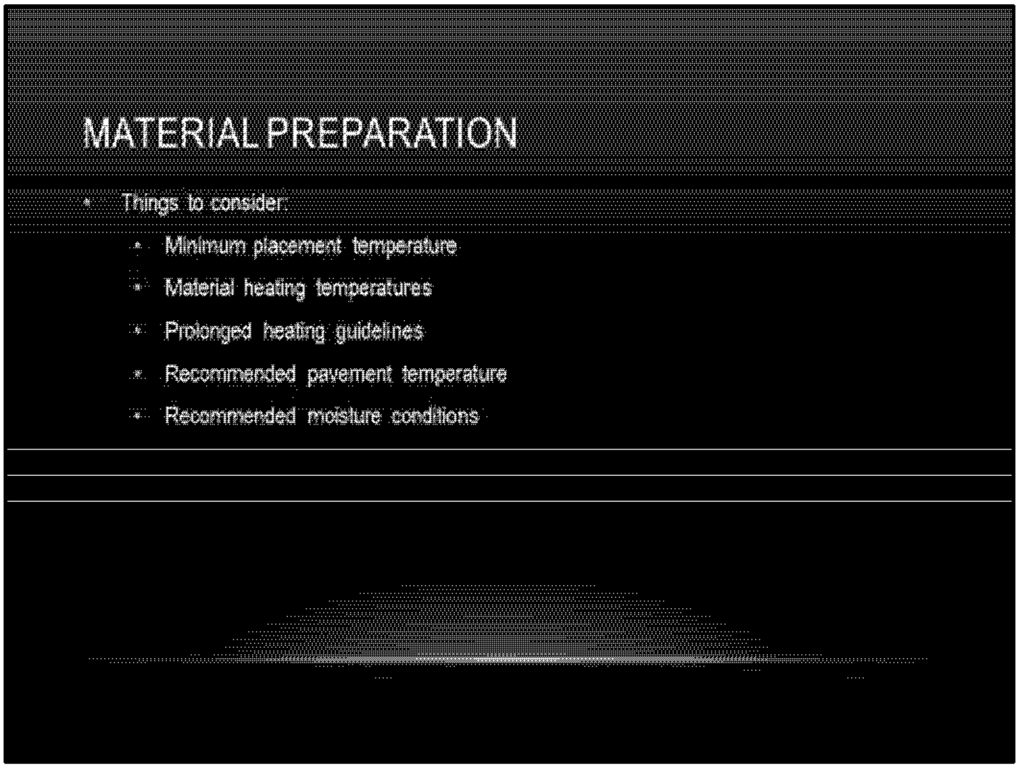
- Use equipment capable of delivery a pressure of 2,000 PSI

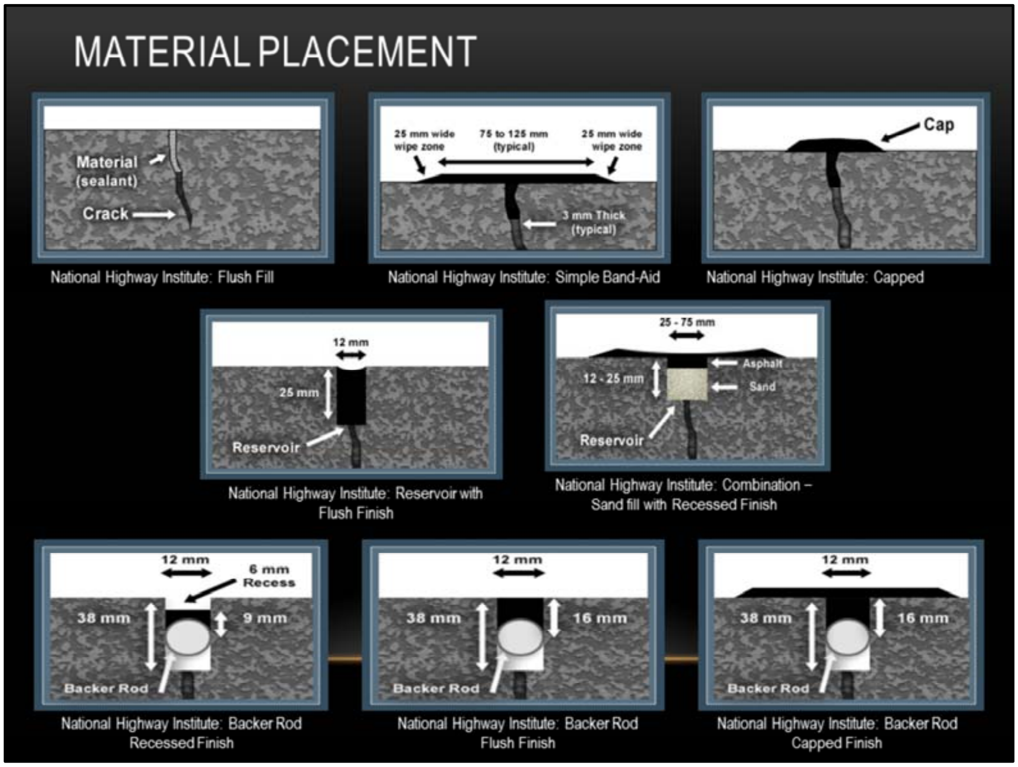
<u>Hot-Airblasting</u>

- Cleans and dries the crack while promoting enhanced bonding associated with warm crack edges. (Do not get too hot!)

<u>Sandblasting</u>

- Cleans the crack, but it is a messy process and often requires two phases.


MATERIAL PREPARATION
Things to consider:
Minimum placement temperature
Material heating temperatures
Prolonged heating guidelines
Recommended pavement temperature
Recommended moisture conditions



<u>Filling:</u>
Material is placed in two steps
Placement of a crack fill is a fairly simple process

<u>Sealing:</u>
Recessed reservoirs need to be uniform
If backer rod is used, check its characteristic and placement
Cracks and Joints with Average Opening of 3/8 Inch (10 Mm)
Rout or saw to provide a minimum sealant reservoir of 3/8 inch (10 mm) in width by a nominal 1/2 inch (13 mm) in depth.
Cracks and Joints with Existing Width Greater Than 3/8 Inch
Use backer rod or clean dry sand. Clean cracks and joints of all foreign material to a depth necessary to accommodate the sealer material and the backer rod,

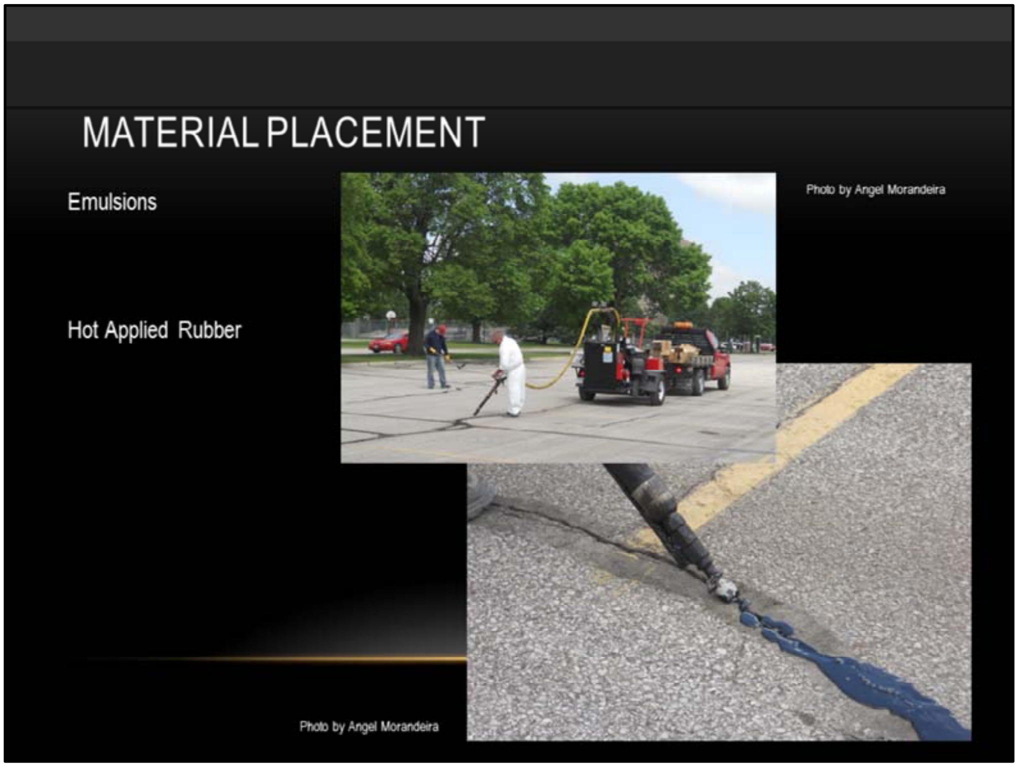
<u>Both Filling and Sealing:</u>
Material should be place from bottom up, as continuous as possible
Constantly check the temperature of the material
Application rates are important with each material

-Want to go bottom up to reduce amount of air trapped underneath

-If material temp is not checked over heated material can suspend the operation and under heated material can cause flow problems with the material

-Sealing need to have a uniform base to adhere to as well as needing to prevent traffic and plow damage

-Over applied material can cause fat spots, localized tenderness, and flushing while under applied material will not yield the expected results.



The material selected will in part determine the application method. Typically, asphalt emulsions are applied directly to the cracks. Hot applied rubber modified sealants, especially asphalt rubber, have excellent adhesion and do not require a thin sand coating (blotter coat) prior to traffic use. Emulsions must be blotter-coated prior to being trafficked. Emulsions may be applied via gravity feed devices, such as pour pots, or via pressure hoses. Some emulsions may require heating to achieve an appropriate application viscosity. Hot-applied rubberized sealants need to be agitated and heated and maintained at the correct temperature throughout their application. For polymer and rubber-modified materials, control of temperature is important in preventing degradation. For hot-applied fiber-filled materials, the fiber may settle and require agitation. For such materials, indirect oil heating is recommended. The required capacity of sealant or filler application equipment is determined by the job size. Preheating the material before use is advisable to ensure optimal productivity. Figure 20 illustrates a hot pressure feed sealing operation and a gravity-fed pour pot.

The application rate of a sealant or filler is important to the quality of a crack sealing or filling project. Over-applied sealant or filler material can cause problems such as fat spots, localized tenderness, and flushing when treated areas are overlaid with hot mix

Over-banding

For designs that call for it

Sanding

Used for emulsion-based projects

Blotting

Used on high traffic or stop-and-go traffic roads

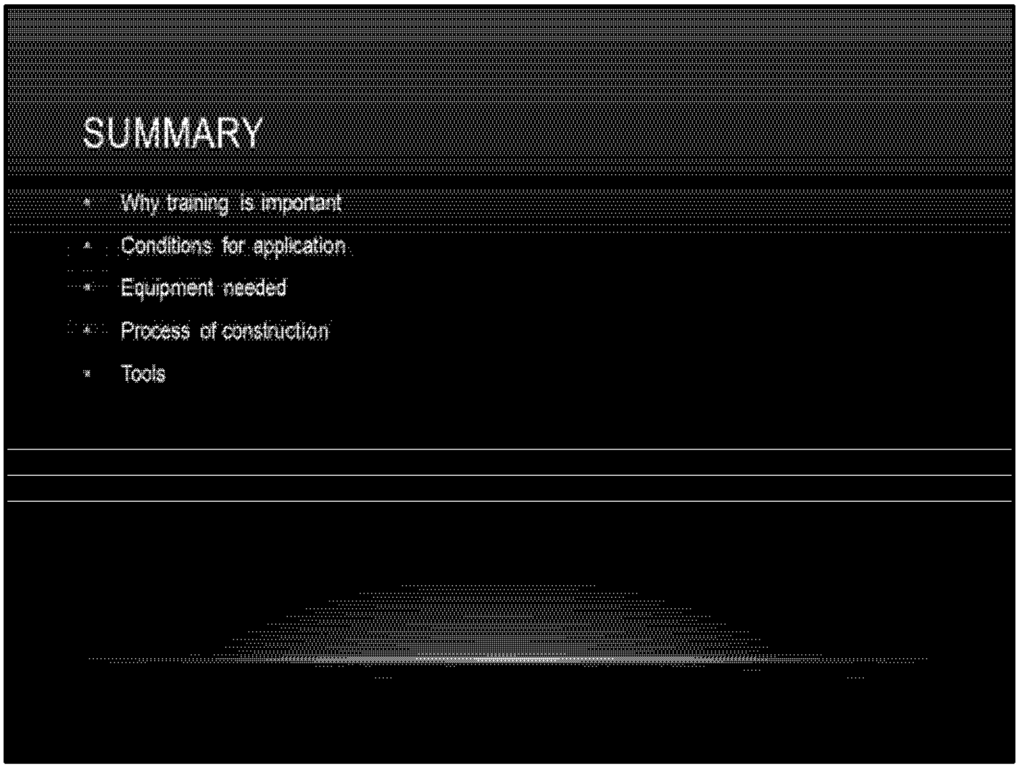

BAD PRACTICES
National Highway Institute
Photo by John Mallen
National Highway Institute

Crack Fill/Seal Construction Checklist		✓
Surface Preparation	Have oily residues been scrubbed from the pavement?	
	Has the surface been clean, dried, and broomed?	
	Have cracks been cleaned?	
Weather Requirements	Have air and surface temperatures been checked at the coolest location on the project?	
	Do air and surface temperatures meet agency and sealant/filler manufacturer requirements?	
	Are freezing temperatures or rain expected?	
Traffic Control	Do the signs and devices used match the traffic control plan?	
	Does the work zone comply with the IDOT's traffic control policies?	
	Are the flaggers holding the traffic for extended periods of time?	
	Are there any traffic control signs still set up that can be removed because they do not apply?	
Sawing/Routing Unit	Is a saw or router to be used?	
	Is the unit fully functional?	
	Are the cutting bits sharp to avoid spalling or cracking?	
	Are the cutting bits correct size?	
	Is all equipment free of leaks?	
Sealing Unit	Is the sealing unit functional?	
	Are the moisture and oil filters on the compressor clean and functioning?	
	Does the unit have temperature control? If so, is it working?	
	Does the sealing unit provide adequate pressure to deliver material to the crack at an appropriate rate?	
	Is a pour pot being used?	
	Is a kettle applicator being used? If so, is it being kept at least partially full at all times?	
	Is the applicator unit re-circulating during idle periods?	
	What method is being used to ensure that the crack sealant or filler is flush with the pavement surface?	
	Is all equipment free of leaks?	

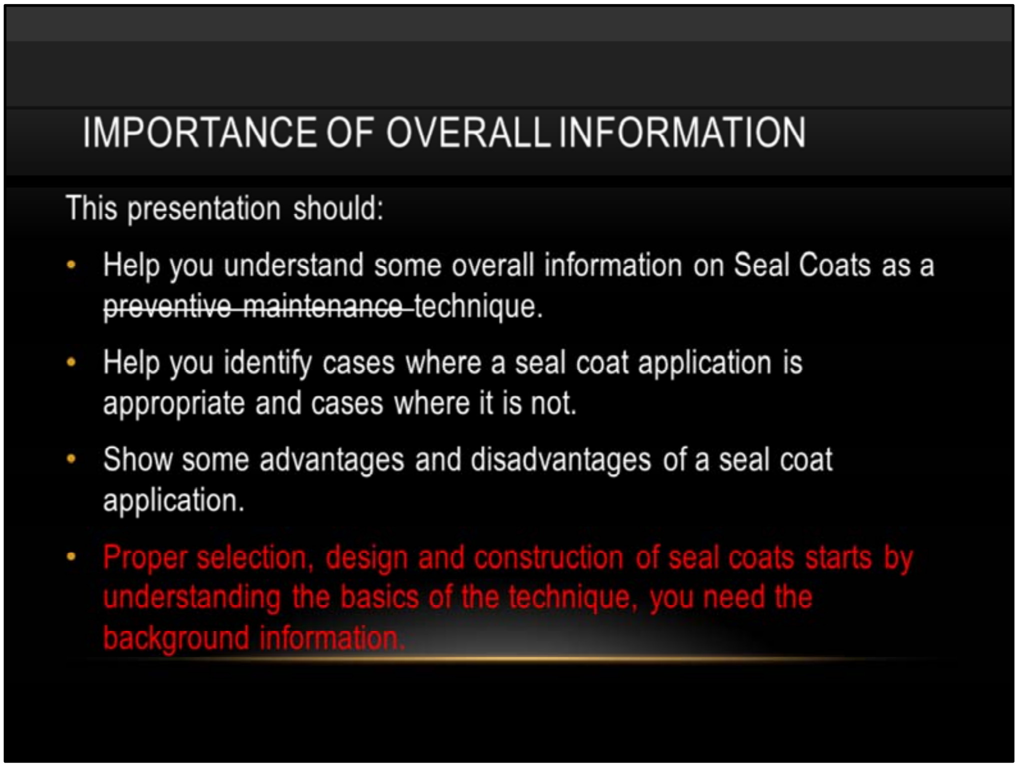
CAUSE	PROBLEM						
	All Seals			Emulsion Seals Only			
	Tacky, Picks Up	Re-Cracks Quickly	Bumpy Surface	Separation From Crack Sides	Emulsion Sealer Not Breaking	Emulsion Sealer Breaks Too Fast	Emulsion Sealer Washes Off
Crack Wet					*		*
Sealant Not Cured	*			*		*	
Crack Dirty	*	*		*		*	
Insufficient Sanding	*			*		*	
Poor Finish, Wrong Tools	*	*	*	*		*	
Sealant Too Cold		*	*				
Sealant Too Hot	*			*			
Application Too High	*		*	*			
Application Too Low		*	*				
Sealant Degraded Due to Overheating	*	*	*	*	*	*	*
Rain During Application					*		*

COMMON PROBLEMS

Problem	Solution
Tracking	Reduce the amount of sealant of filler being applied
	For hot applied materials, allow to cool or use sand or other blotter
	Allow sufficient time for emulsions to cure or use a sufficient amount of sand for a blotter coat
	Ensure the sealer/filler is appropriate for the climate in which it is being placed.
Sealant Loss	Ensure cracks are clean and dry.
	Increase temperature of application.
	Use the correct sealant for the climate.
	Allow longer cure time before trafficking.
Bumps	Check squeegee and ensure it is leaving the correct flush finish.
	Have squeegee follow more closely to the application.
	Decrease the viscosity of the sealer.
	Change the rubber on the squeegee.

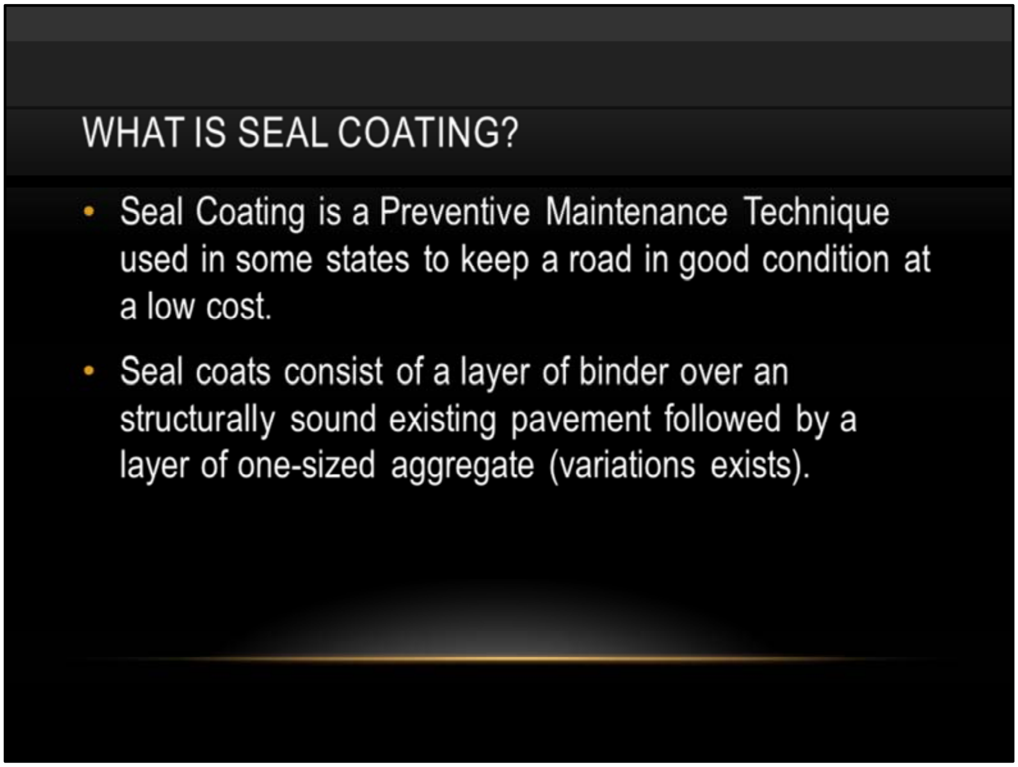

SUMMARY
Why training is important
Conditions for application
Equipment needed
Process of construction
Tools

PAVEMENT PRESERVATION: SEAL COATING



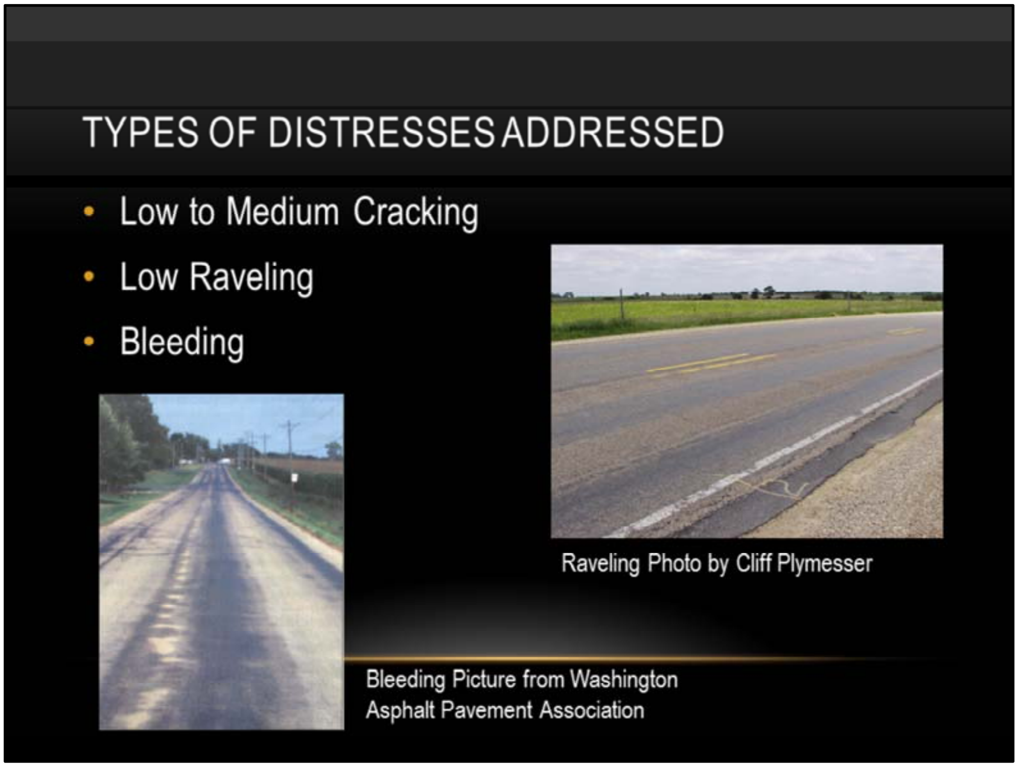
Objectives of the presentation:

1. Provide overall/background information on seal coats as a preventive maintenance technique.
2. Show visual images of appropriate and inappropriate cases to apply seal coats.
3. Identify advantages and disadvantages of seal coats.
4. It all starts with a background information.



Seal coats do not add structural value to the road, it is a treatment to keep the road in good condition for a period of time at a low cost.

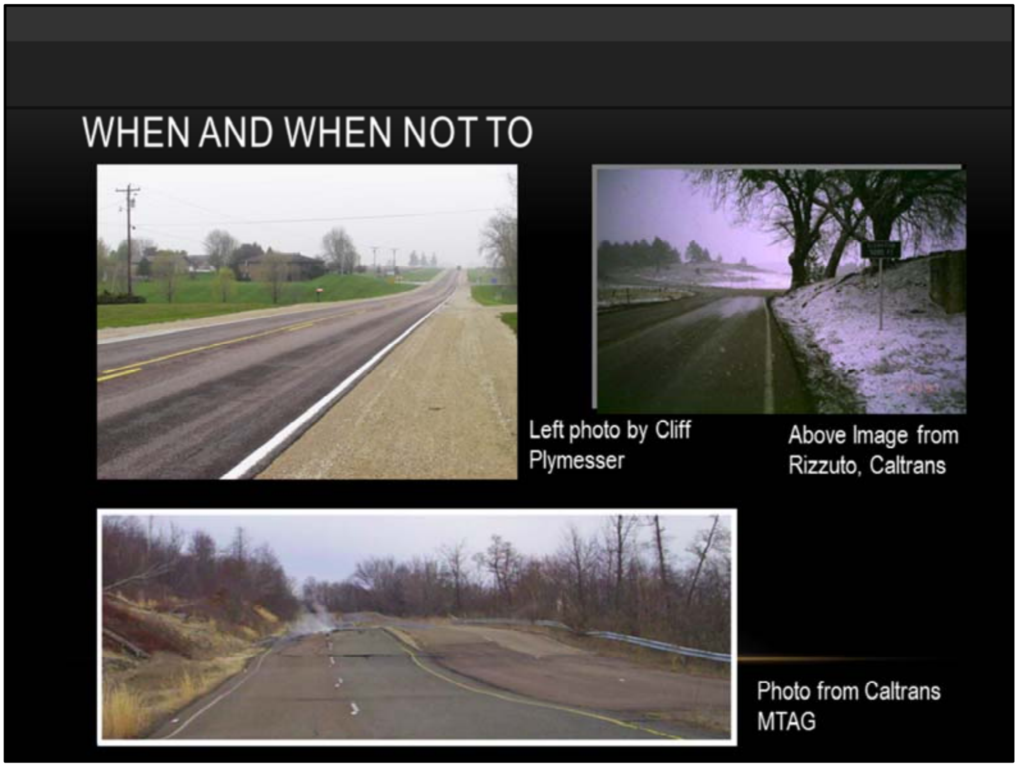
1. Distributor applies a layer of binder to the road.
2. As seen in the first picture, a spreader follows closely behind at the same speed as the distributor applying the aggregate to the surface.
3. A couple of minutes later, rollers pass over the surface to embed the aggregate with the binder. (providing stability and skid resistance)
4. Brooms go thru the surface later on to sweep away excess aggregate.
5. Open to traffic.



Cracks are usually transverse or longitudinal. Transverse cracks commonly represent thermal failure due to expansion/shrinkage. Longitudinal cracks commonly represent structural failure.

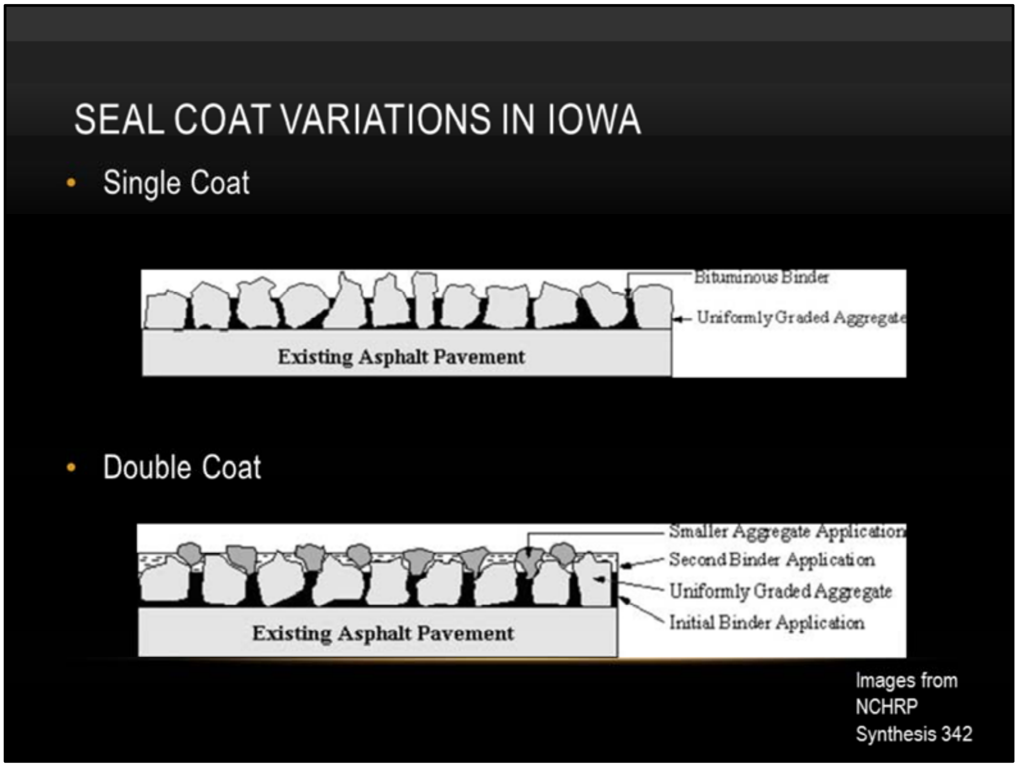
Raveling – also known as weathering, aggregate or binder has worn away due to oxidation, traffic, snow plow.

Bleeding – occurs when asphalt binder is pushed to the surface providing a shiny black appearance. Usually happens shortly after application and represents a mix too rich in binder.



When – first picture shows some raveling but no major imperfections or unsound structure.

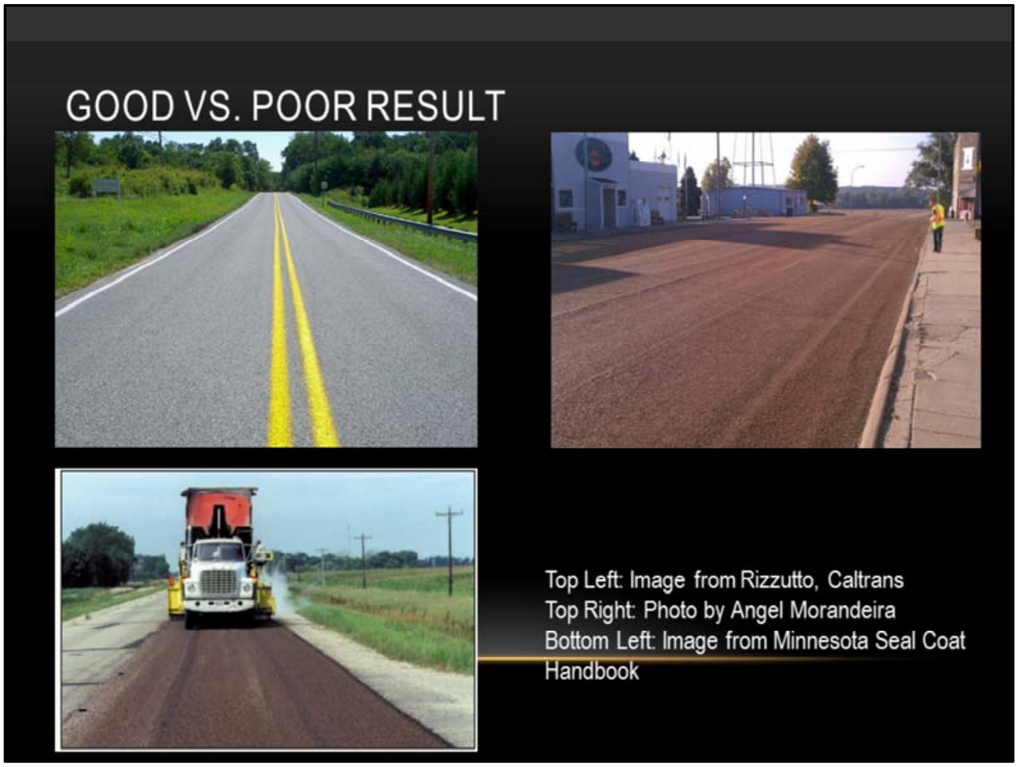
When not to – severe climate (snow, rain, high wind)
structurally unsound road, Picture is extreme case



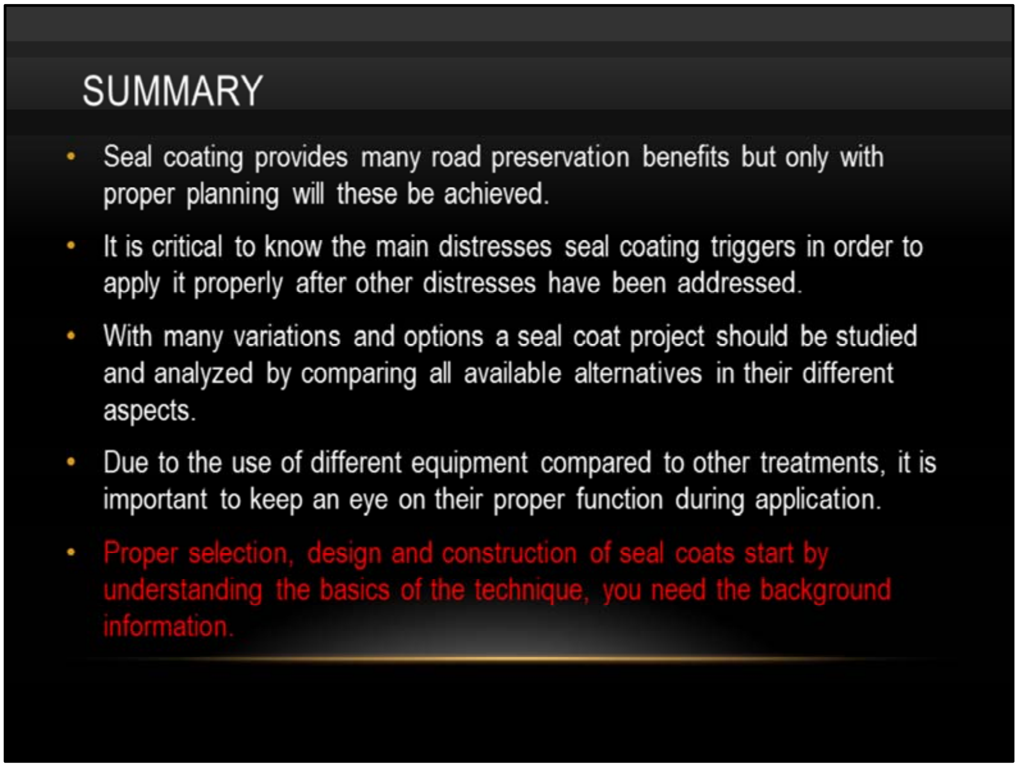
Single coats are commonly used when no special situations are present that would require the use of a double coat or any other variation.
Double coats provide less noise, additional waterproofing and are more robust than single coats, therefore they could be used when there is a high percentage of truck traffic or steep grades.

Although single and double layer coats are the two types of seal coats used in Iowa, other variations do exist and are covered in another training module called Seal Coat Variations.

Proper function and timed sequence of equipment is key to proper application. Checking for nozzle angles, nozzle height, and the possibility of nozzles getting clogged on the distributor are some of the inspection responsibilities.



Top Left photo shows the result of a proper seal coat application where it looks uniform and with no imperfections.
Top Right shows an uniform application but major distresses like rutting were not addressed correctly before application.
Bottom left picture shows an application either rich on binder or low on aggregate as the truck wheel path is exposed immediately after passing.



Conclusion:
1. Benefits can only be achieved with proper planning: selection, design and application.
2. Major distresses like potholes and major cracks just to name a few should be addressed prior to application.
3. Different types of seal coats and the availability of variations like pre-coated aggregates should be analyzed before decision.
4. Careful and constant inspection is crucial for a proper application.

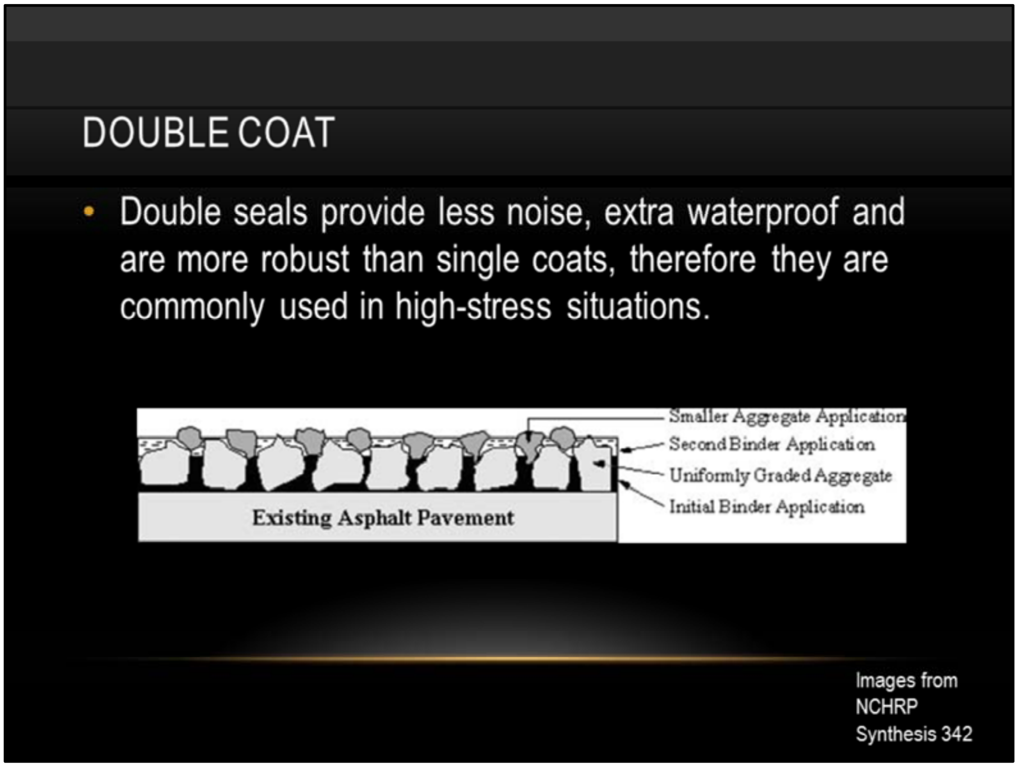
PAVEMENT PRESERVATION: SEAL COAT VARIATIONS

There's more than single and double coats

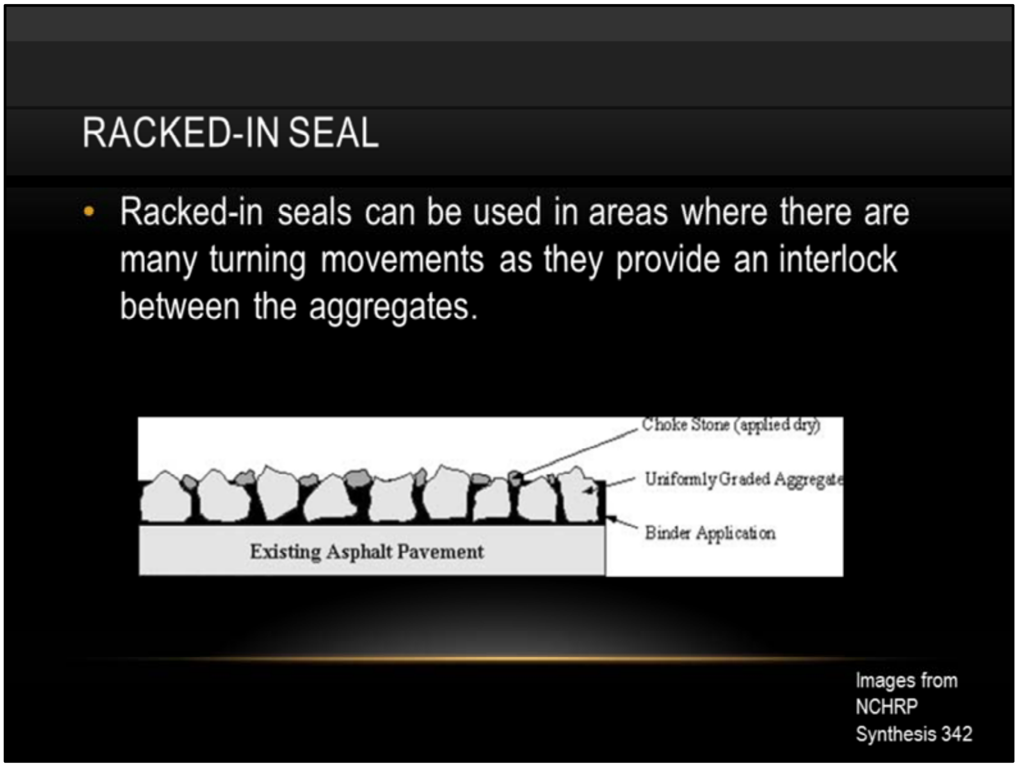
SINGLE COAT

- Most common application of seal coats. Commonly used when there are no special considerations that would indicate the need to apply another type of seal coat.

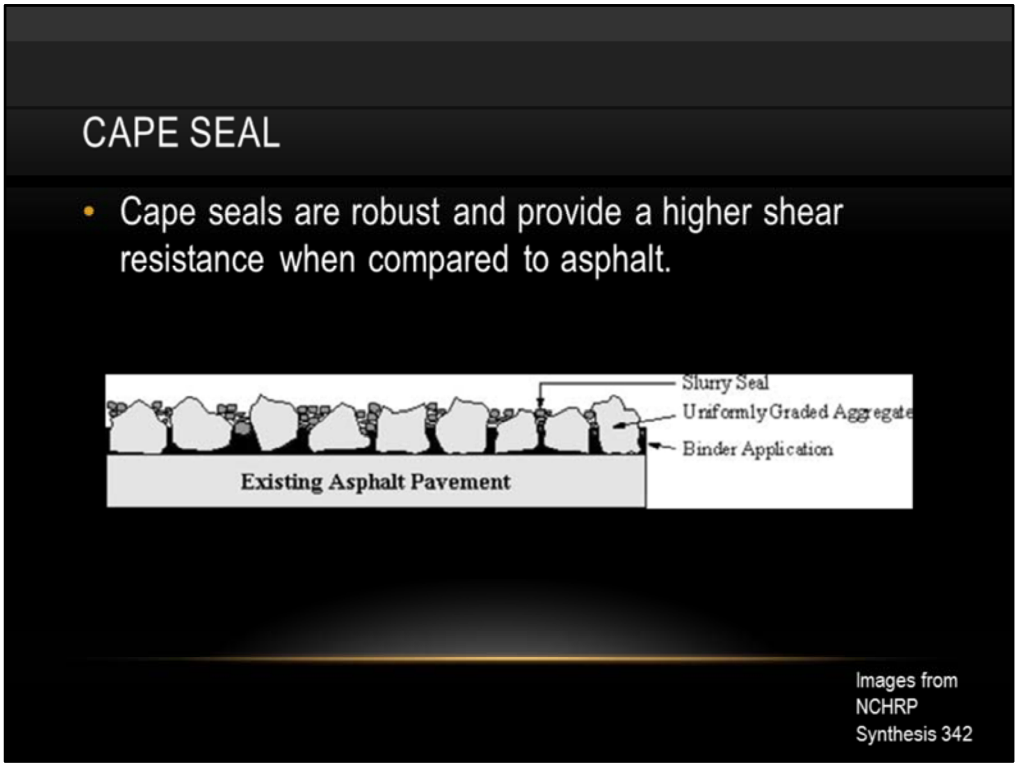
Images from NCHRP Synthesis 342



By high stress situations we mean roads that have high percentages of truck traffic or roads on steep grades.



Choke stone is applied to prevent the larger aggregates to dislodge before the binder is fully cured.



A slurry seal is a preventive maintenance technique that and is discussed in more details in other training modules.

INVERTED SEALS

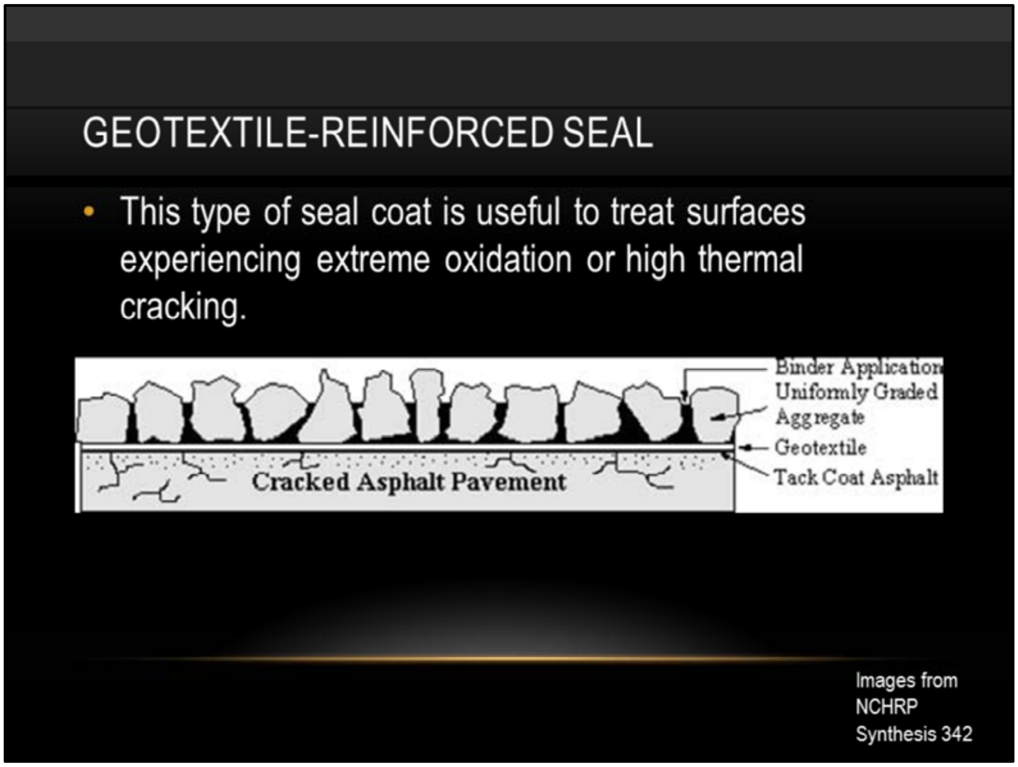
- Called inverted due to the fact that it is a double seal upside down. Inverted seals are commonly used when needing to correct a bleeding surface.

Images from NCHRP Synthesis 342

SANDWICH SEAL

- Sandwich seals are commonly used to restore surfaces on raveled surfaces.

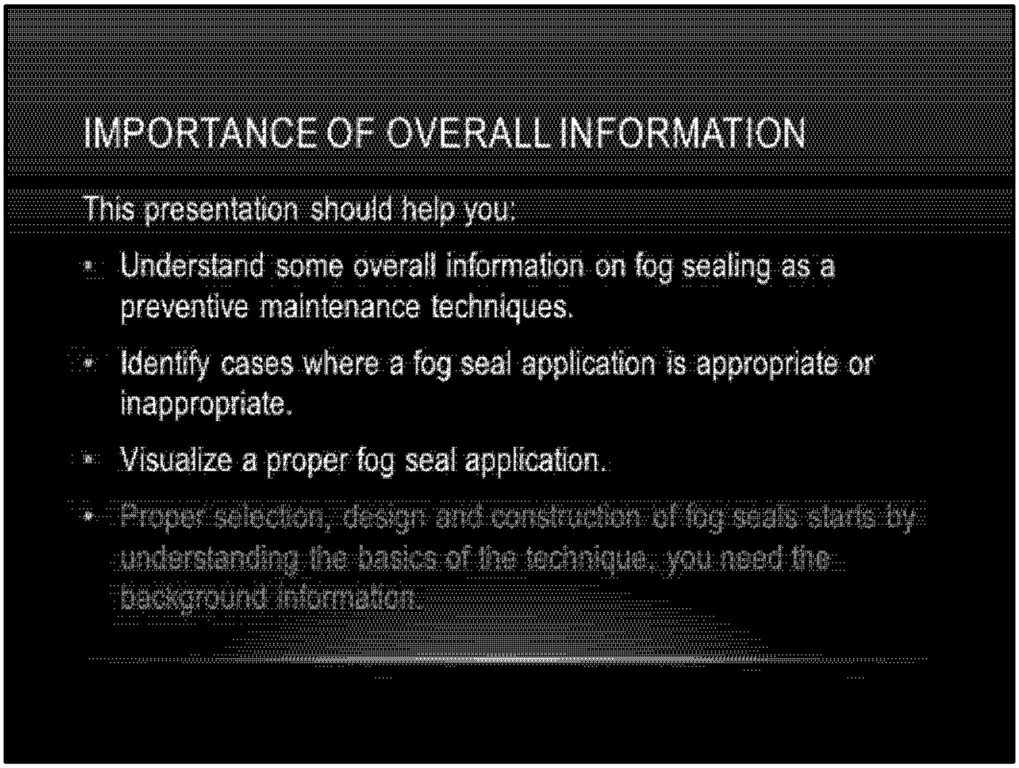
Images from
NCHRP
Synthesis 342

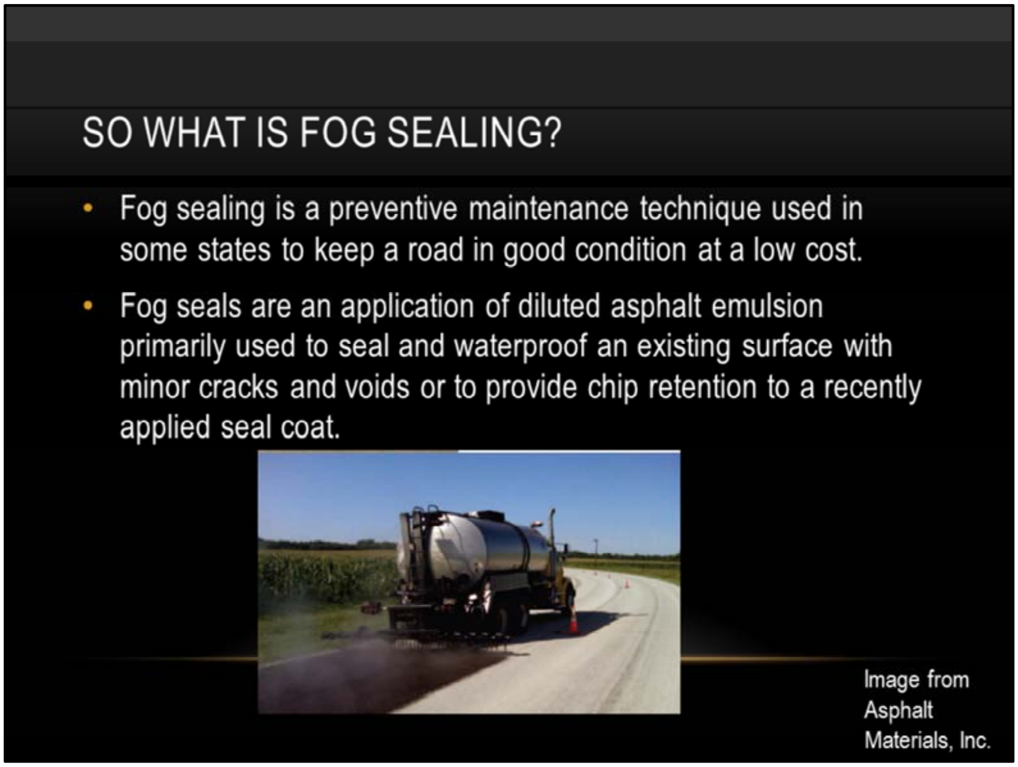


Geotextiles can enhance the performance of a conventional seal coat. A layer of geotextile material is placed over a layer of tack coat asphalt over the surface before applying the seal coat.

Geotextile Reinforced Seal
Photo from Caltrans MTAG

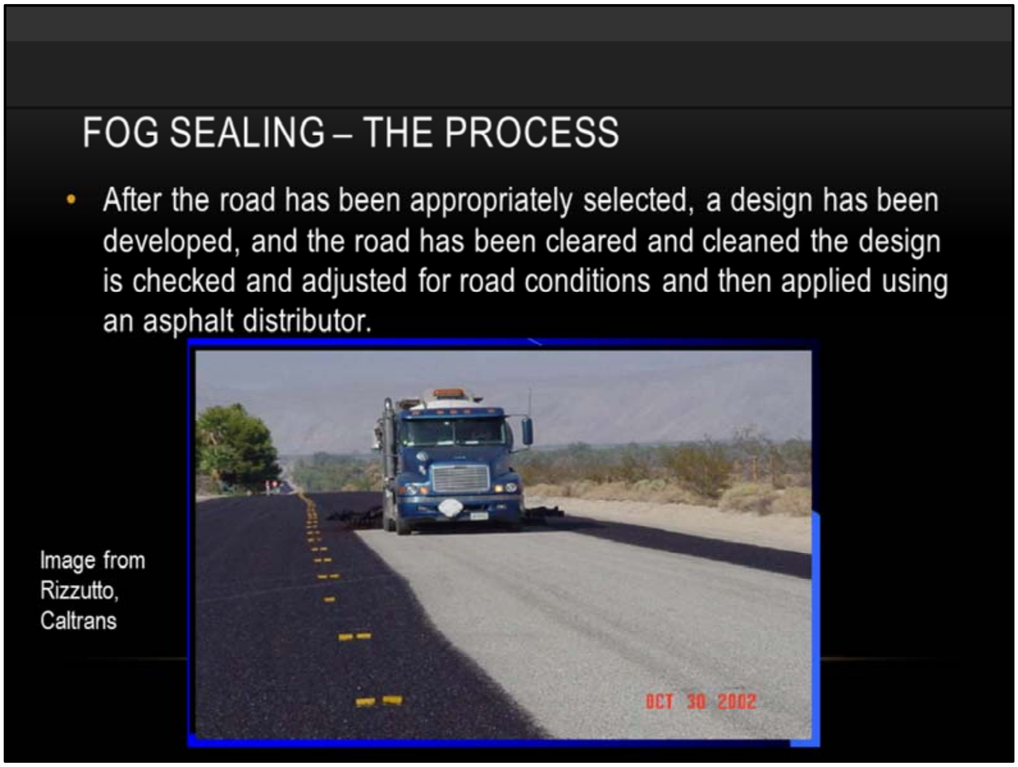
PAVEMENT PRESERVATION:
FOG SEALING


IMPORTANCE OF OVERALL INFORMATION
This presentation should help you:
Understand some overall information on fog sealing as a preventive maintenance techniques.
Identify cases where a fog seal application is appropriate or inappropriate.
Visualize a proper fog seal application.
Proper selection, design and construction of fog seals starts by understanding the basics of the technique, you need the background information.

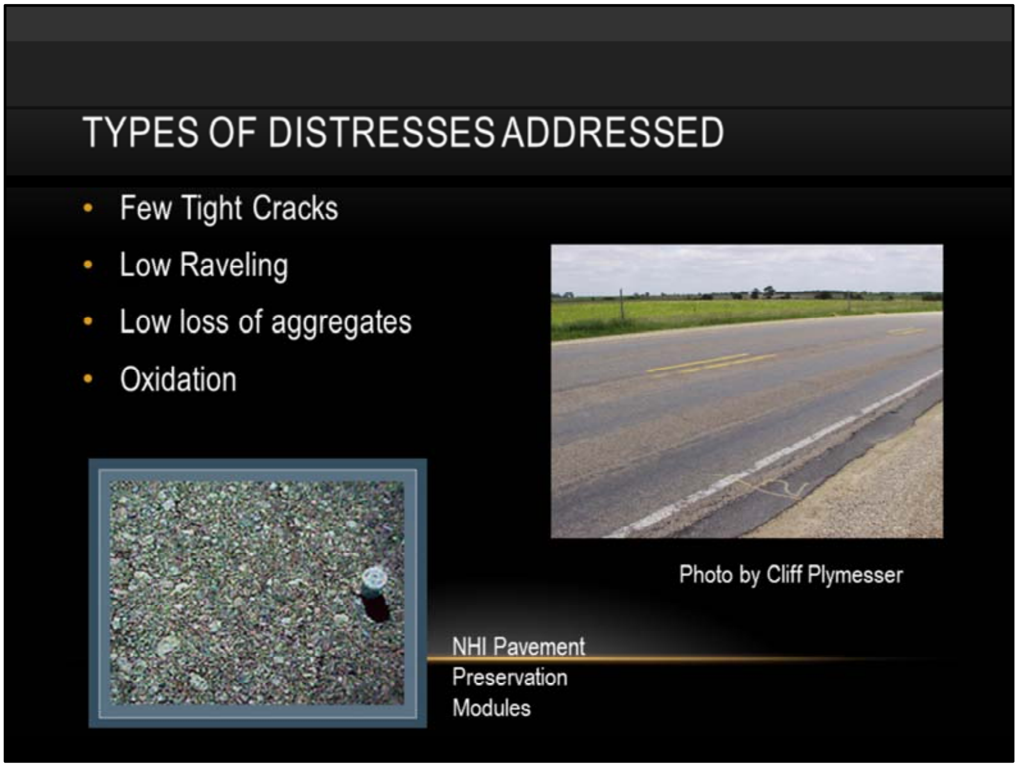


Fog seals are more commonly used after a chip seal has been applied to provide chip retention.
Fog seals are also used to keep a road in it’s present condition for a short period of time before applying another treatment.
They will not repair any major distresses and, as said before, it could be used in roads with minor cracks. In this presentation we refer to minor cracks as really small cracks that not necessarily need crack filling/sealing.

In general the fog seal emulsion should be of sufficient low viscosity to penetrate the voids.



A design is performed beforehand by the manufacturer but it NEEDS to be checked on-site since the actual road conditions determine the application rate.
This is commonly determined by applying a layer of diluted asphalt on a 1sy2 area and observing the degree of absorption, then adjusting.
For more information on regards to designing and adjusting for application rates and dilution please refer to the fog seal design presentation.
In some cases a sand application follows a fog seal, and that will be covered later on this presentation.

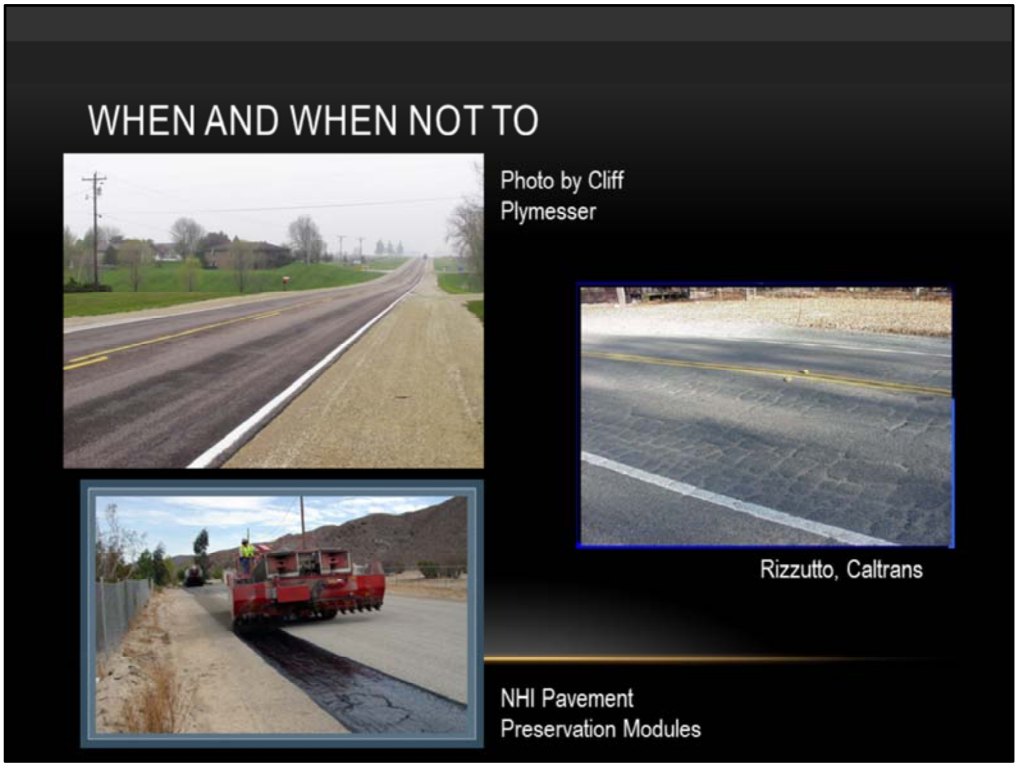


Few tight cracks – again, this are cracks that are extremely small as we can see in the low left picture.

Raveling - also known as weathering, aggregate or binder has worn away due to oxidation, traffic, snow plow.

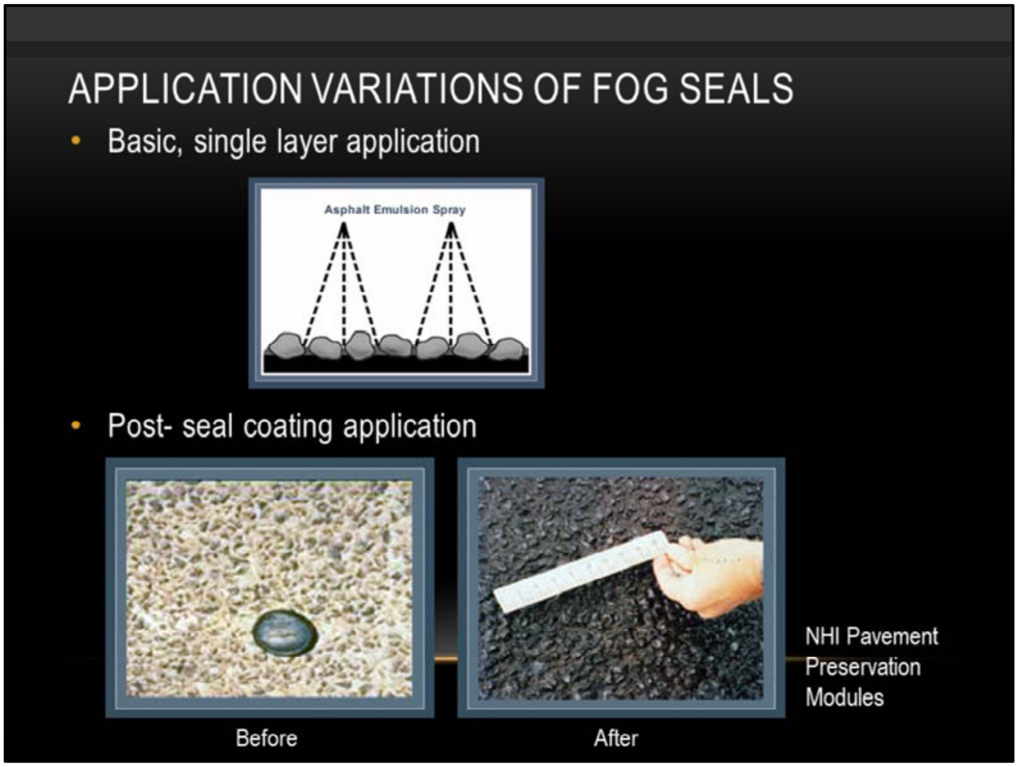
Oxidation – this is the effect of weather and can be observed on roads with a light grey appearance.

As seen, fog seal will not repair any kind of major distresses like rutting, medium to large cracks, potholes, etc.



When to: if a road is experiencing some of the minor distresses mentioned before, then a fog seal could be a good application to keep the road in good condition. Also, after a seal coat has been applied and we want to provide some type of chip retention to avoid flyrock or chips getting dislodged, then fog seal can be helpful.

When not to: roads with major distresses as seen in both of this pictures. Also, when weather conditions are not favorable.



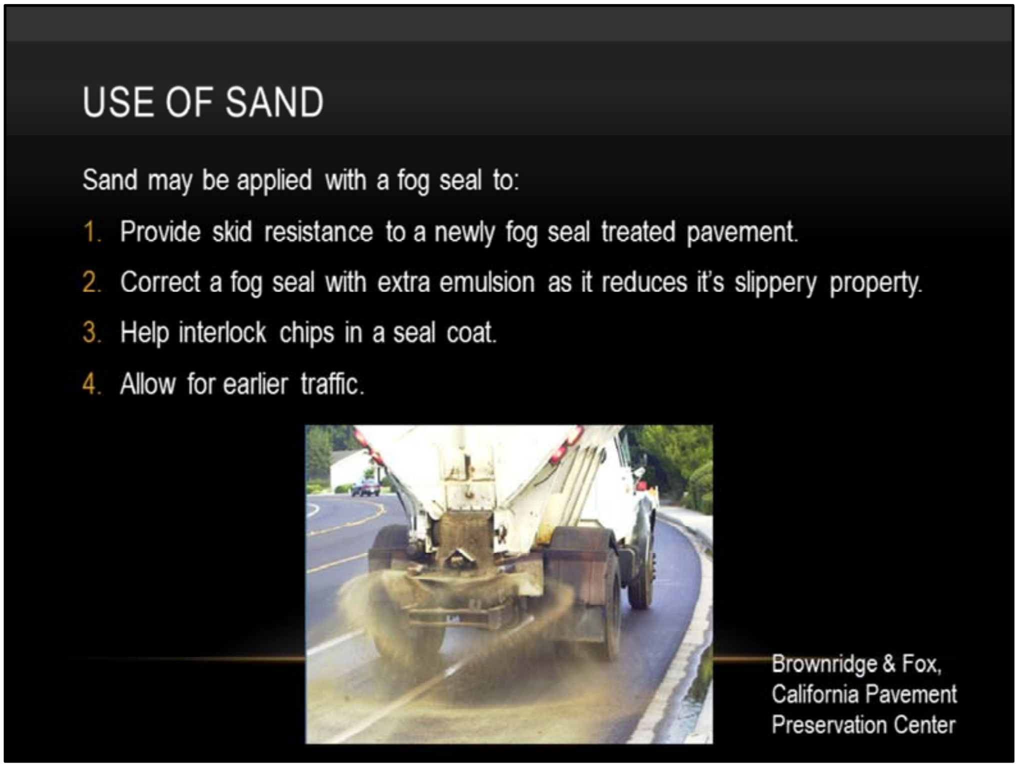
As mentioned before, fog seals are commonly used in two cases:

1. A single layer of emulsion used to weatherproof a surface.
2. After a chip seal to provide chip retention.

Reclamite: oil emulsion
PASS: asphalt, oil and additives
Topien C: asphalt, oil and additives.

So the rejuvenator seal penetrates the existing oxidized asphalt and they chemically combine to create a strong, durable, and flexible surface, from there rejuvenate.

From my understanding, here in Iowa the use of rejuvenators is not common but anyways I'm putting it out there so that you know that they could be applied, it is an option.

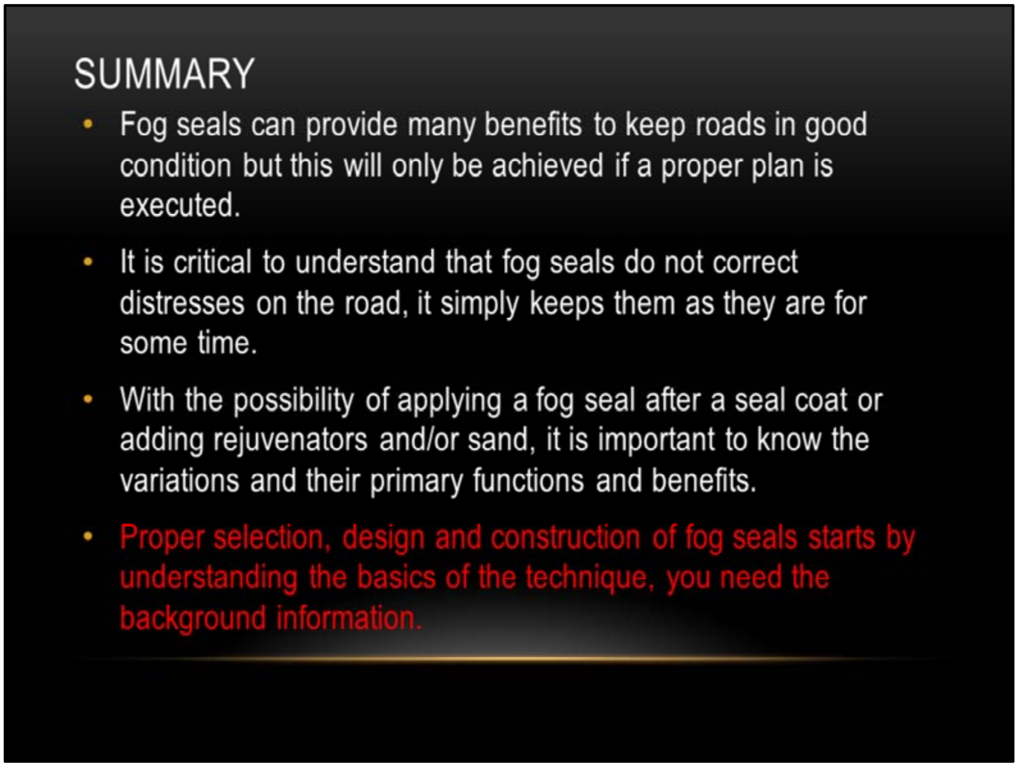


It is my understanding that a sand application following a fog seal is extremely common in Iowa, maybe it is always done.
According to the literature it is an option in other states, some of them use it, some don't.

In the case sand will be used, rollers can also be used depending on the aggregate size.

First picture shows a proper application of a fog seal, as the appearance looks uniform.

Second picture shows an improper application of a fog seal, as the emulsion was either diluted incorrectly or applied incorrectly. In this case the emulsion did not penetrate the surface properly leaving excess asphalt over the surface. This could be a problem as it leaves a slippery surface vulnerable to accidents.



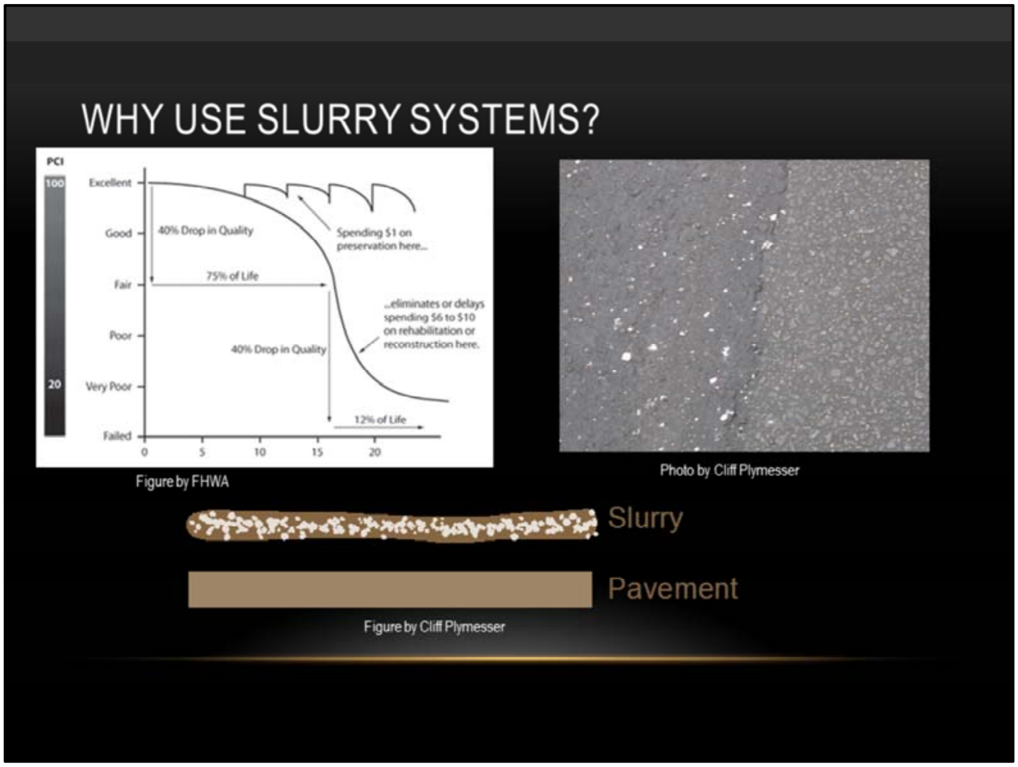
Some of the benefits:

1. Provides chip retention for chip seals
2. It gives the appearance of a new HMA layer
3. With a darker appearance after a seal coat, the temperature rises allowing a chip seal to cure quicker (good for late season chip seals).
4. With a darker appearance, the amount of paint for pavement markings is lower.


PAVEMENT PRESERVATION:
SLURRY SYSTEMS

AFTER THIS TRAINING YOU SHOULD:

- Know why Slurry Systems are useful
- Understand when and when not to use Slurry Systems
- Understand what the types of treatments are
- Understand the basic difference between microsurfacing and slurry seal
- Understand what equipment is used



<u>Extending the Pavement Life</u>

- Does not *improve* but *preserves* the structural integrity of the surface by reducing the environmental damage and deterioration.
- A slurry system project done correctly on the correct road will substantially extend the pavement service life.
- Slurry system treatments can extend the life of a pavement 5-7 years

<u>Decrease Pavement Permeability</u>

- As pavements grow older they become more and more permeable allowing air and moisture to infiltrate their surfaces. This can cause many problems and lead to failure, but a slurry system treatment can seal a pavement and reduce air and moisture infiltration.
- Moisture and air infiltration can lead to weathering, raveling, and surface cracking of the pavement surface.

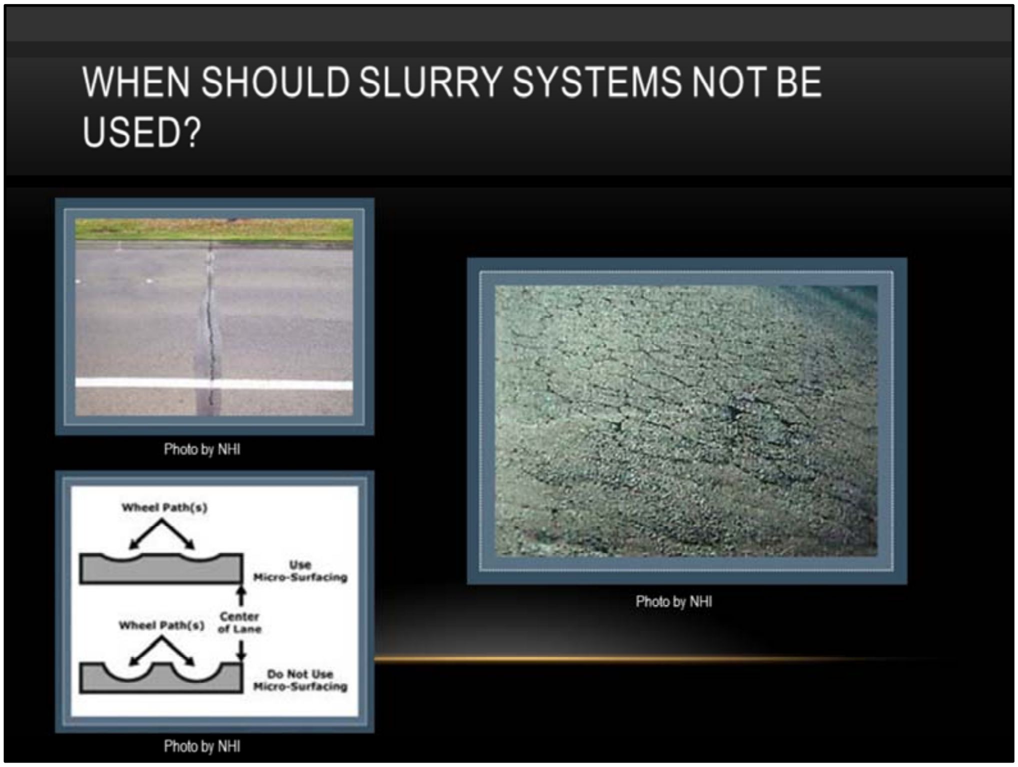
<u>Improve Surface Friction</u>

- Certain mixtures can be used to increase the skid resistance of a pavement. Many pavements lose their friction over time especially in areas where frequent stops are made or where stresses are constantly applied to pavement.

<u>Cost Effective</u>
<u>Corrective Maintenance</u>

<u>Both</u>
- Correct Raveling, seal oxidized pavements, improve waterproofing characteristics, and restore skid resistance.

<u>Micro</u>
- Correction of minor surface profile irregularities
- Rut Filling
- Night Work



Improve Structural integrity

Fill Cracks (Alligator Cracking, on-going rutting, Bumps and Depressions, Potholes)

Solve reflective cracking problems

Do not use Slurry Seal at night.

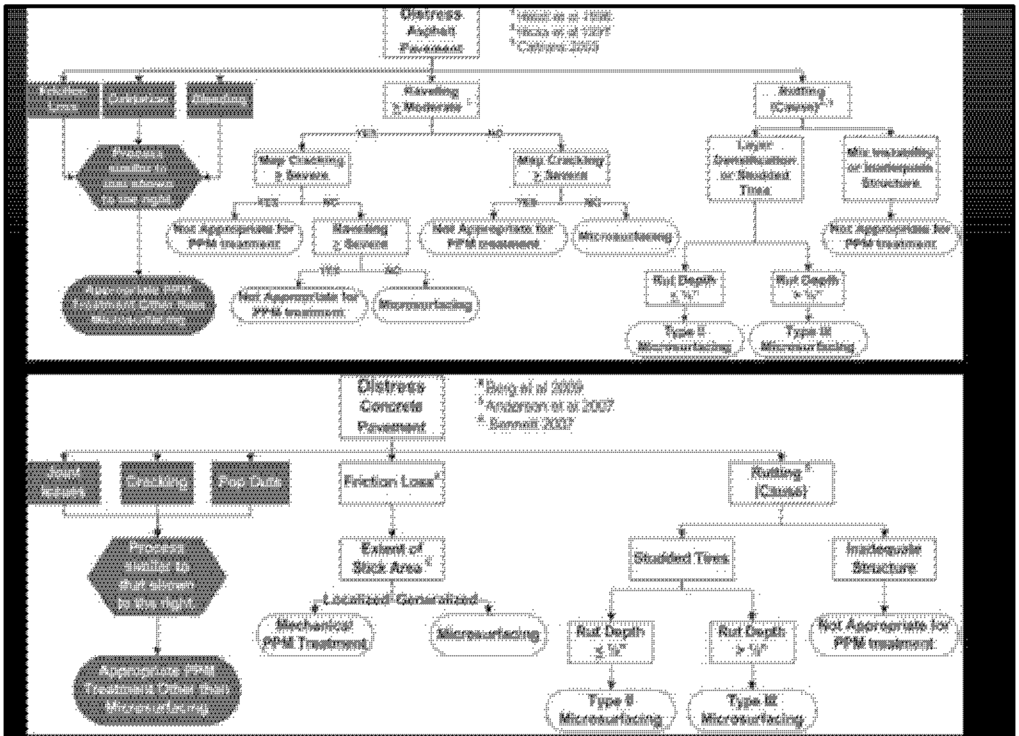
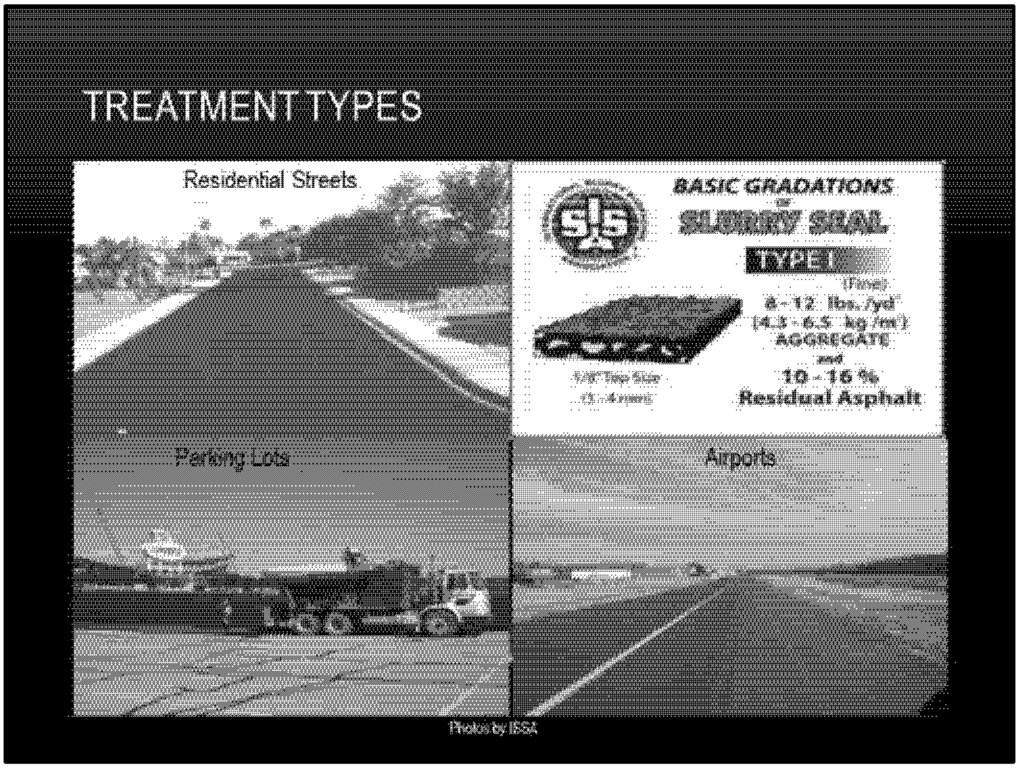


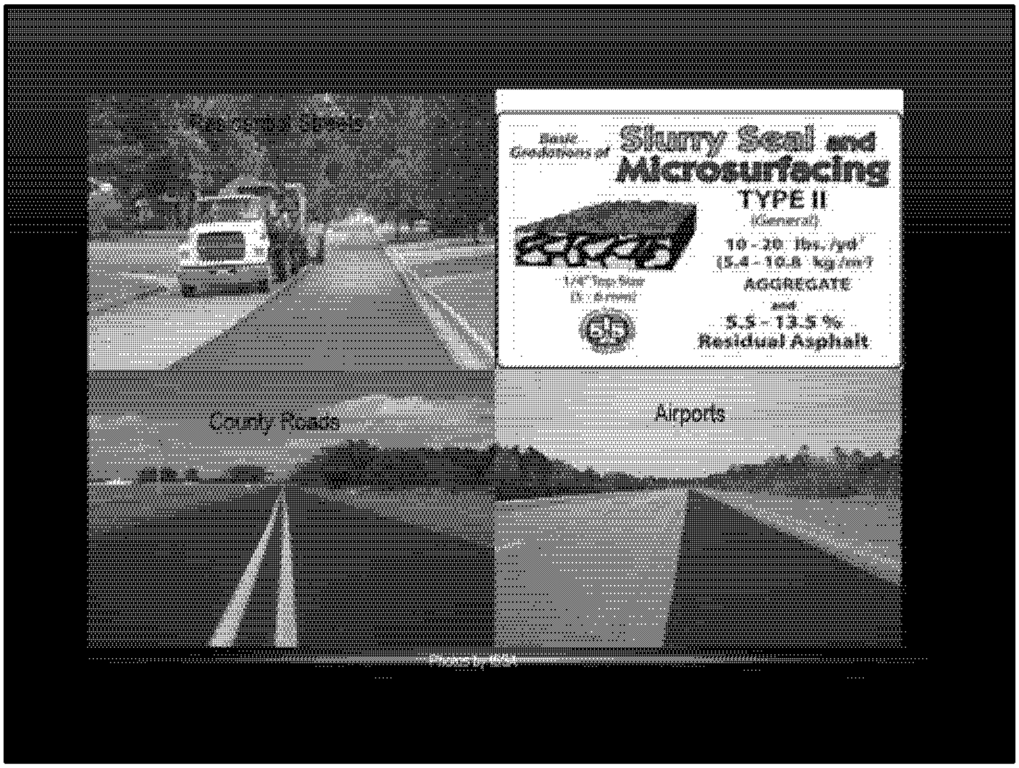
Figure by Douglas Gransberg et al

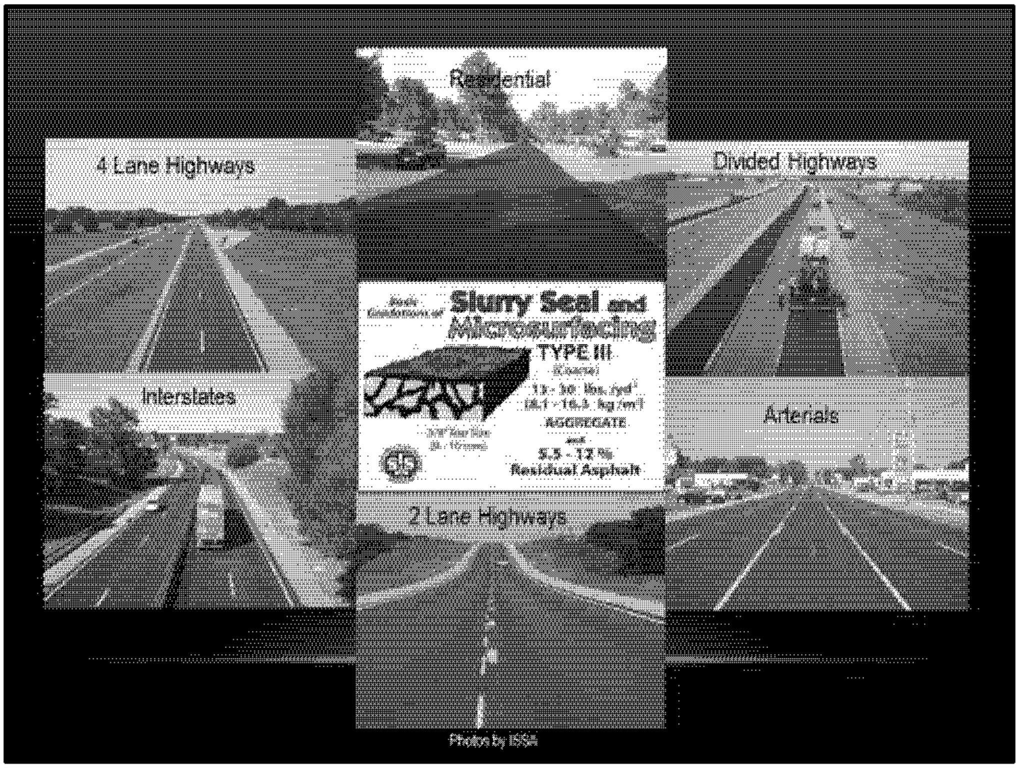
SLURRY SEAL VS. MICROSURFACING

Differences in:	Microsurfacing	Slurry Seals
Asphalt Emulsion	Always polymer modified and cationic, quick set	Could be polymer modified
Aggregate Quality/Gradation	Stricter specification for sand equivalent, use only Type II and Type III aggregate gradations	Can Use Type I, II, or III aggregate gradations
Additives/Break	Chemical break time is largely independent of weather conditions	Breaking and curing time depends on weather conditions (slower in more humid and cooler conditions)
Mix Stiffness/Equipment	Stiffer mix, use augers in the spreader box and secondary strike-off are necessary	Softer mix, augers and secondary strike-off are optimal
Distresses Addressed	Same as Slurry Seal + rut filling, correction of minor surface profile irregularities. Higher durability and night work is possible	Correct raveling, seal oxidized pavements, and restore skid resistance

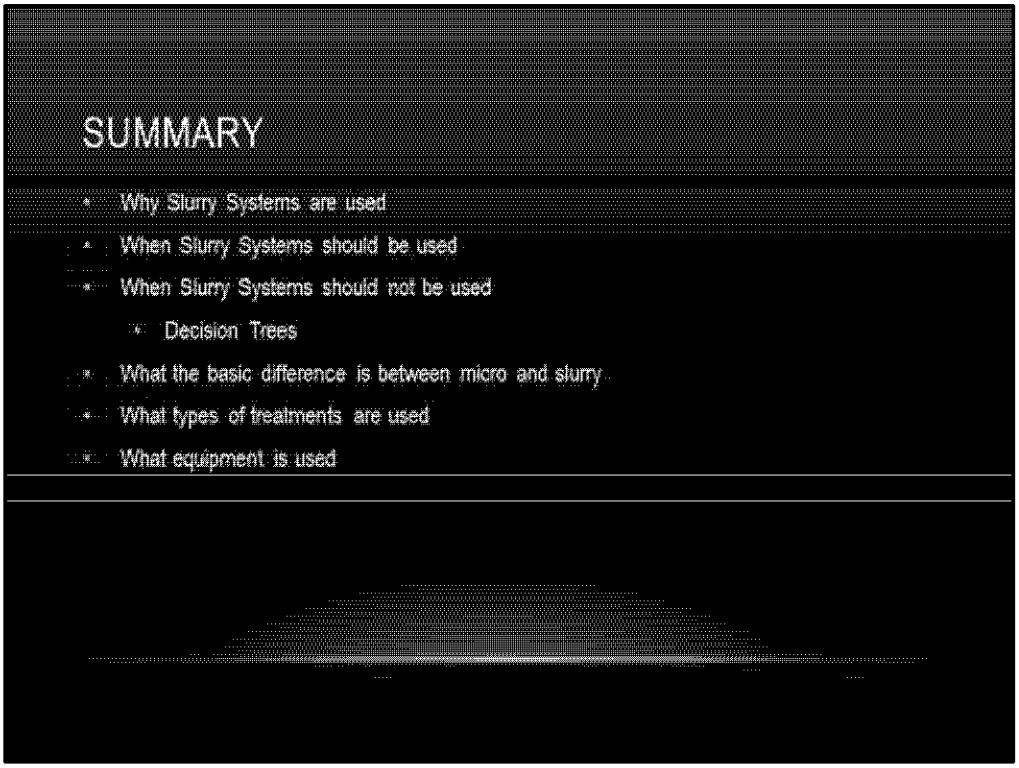
Table by Caltrans


TREATMENT TYPES
Residential Streets
BASIC GRADATIONS
SLURRY SEAL
TYPE I
(Fine)
8 - 12 lbs./yd²
(4.3 - 6.5 kg/m²)
AGGREGATE
and
10 - 16 %
Residual Asphalt
Parking Lots
Airports
Photos by ISSA

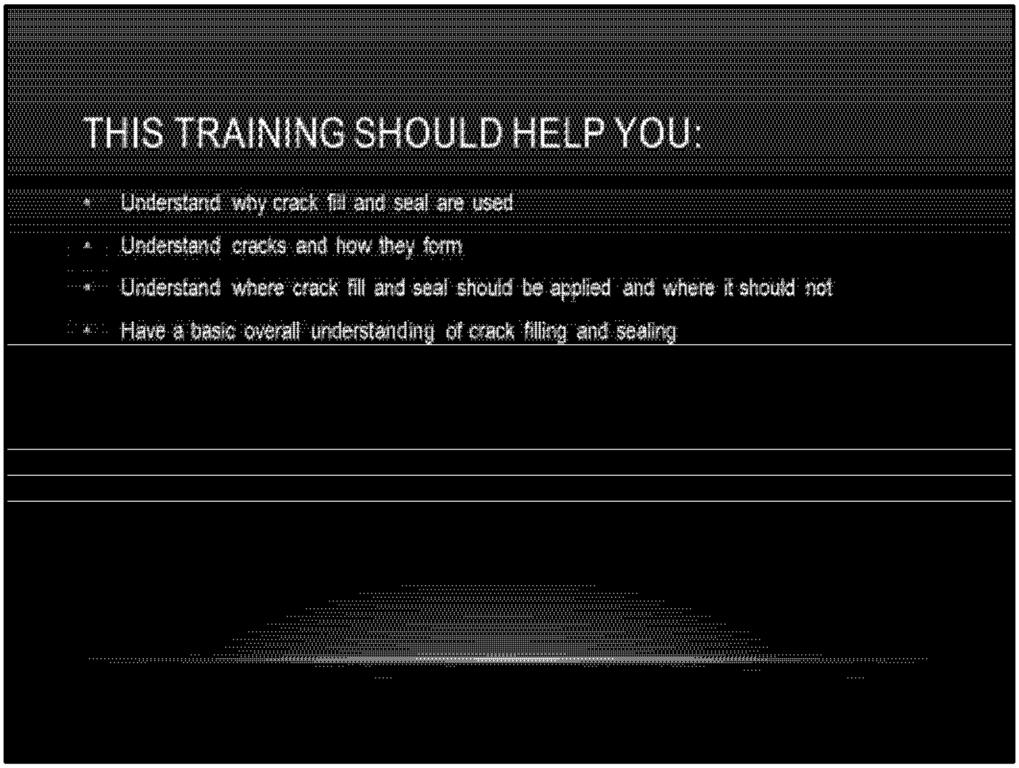

Basic Gradations of
Slurry Seal and Microsurfacing
TYPE II
(General)
10 - 20 lbs./yd²
(5.4 - 10.8 kg/m²)
AGGREGATE
and
5.5 - 13.5 %
Residual Asphalt
County Roads
Airports

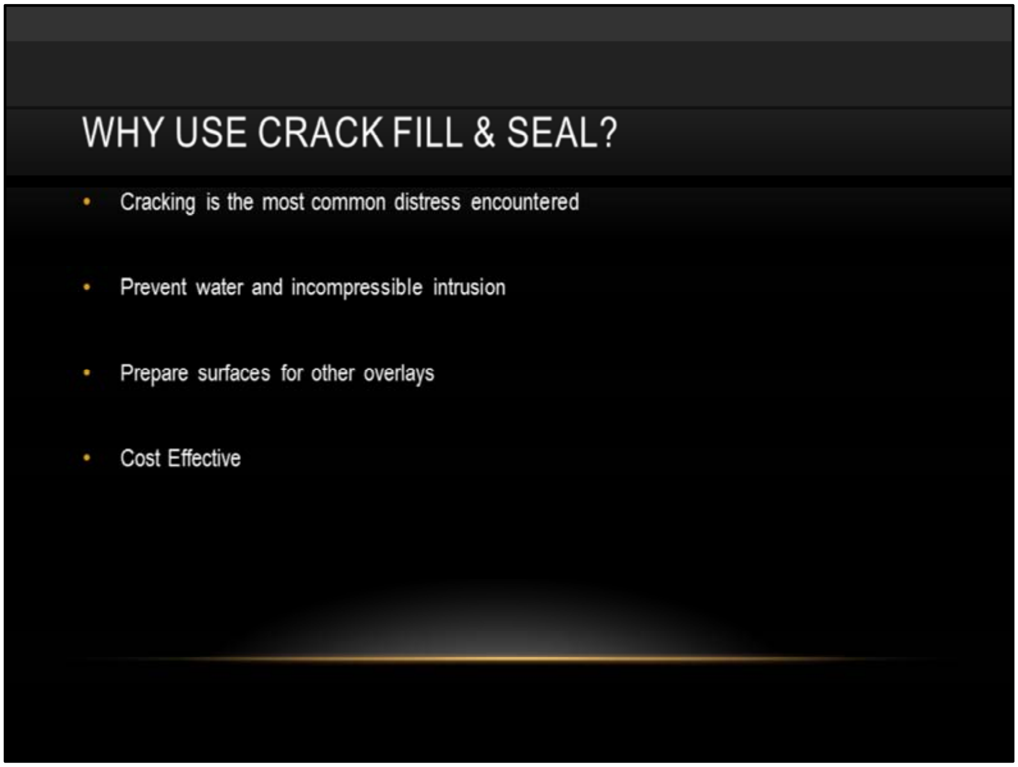

Residential
4 Lane Highways
Divided Highways
Slurry Seal and
Microsurfacing
TYPE III
15 - 30 lbs./yd²
(8.1 - 16.3 kg/m²)
AGGREGATE
5.5 - 12 %
Residual Asphalt
Interstates
Arterials
2 Lane Highways
Photos by ISSA

Continuous Machine has to be used for Microsurfacing.


SUMMARY
Why Slurry Systems are used
When Slurry Systems should be used
When Slurry Systems should not be used
Decision Trees
What the basic difference is between micro and slurry
What types of treatments are used
What equipment is used

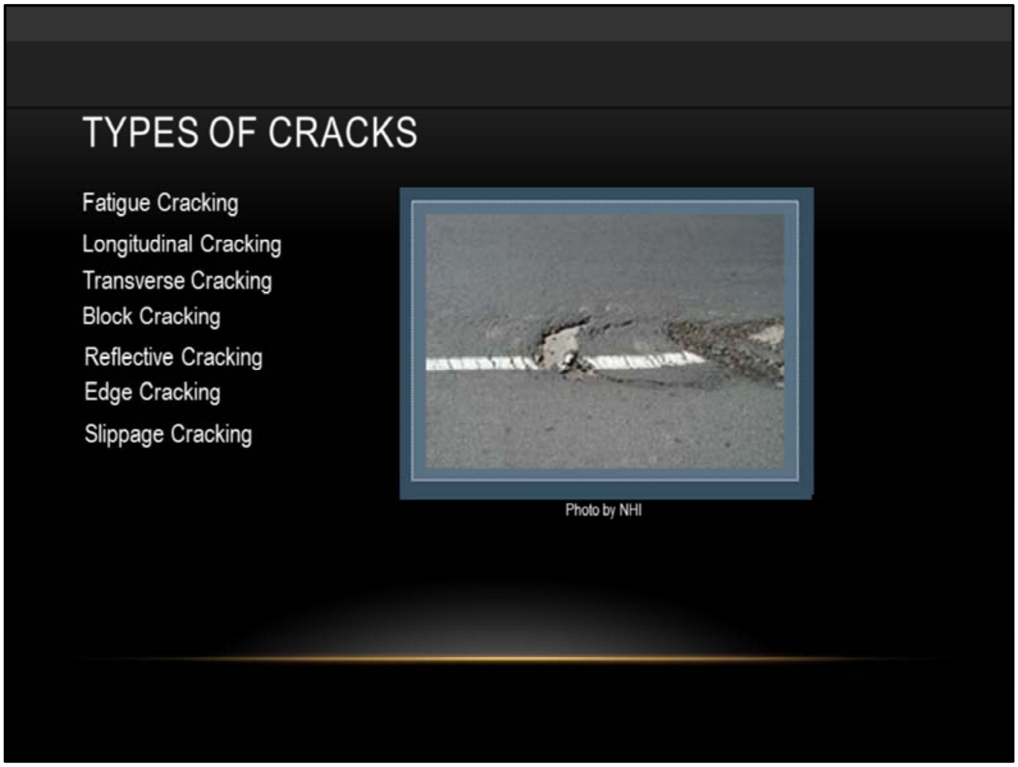

PAVEMENT PRESERVATION:
CRACK FILL & SEAL


THIS TRAINING SHOULD HELP YOU:
Understand why crack fill and seal are used
Understand cracks and how they form
Understand where crack fill and seal should be applied and where it should not
Have a basic overall understanding of crack filling and sealing



Cracks are inevitable and neglect will lead to a more rapid deterioration of the road surface.

Crack Fill/Seal is the least expensive of all PM options. Very easy to do also.



Fatigue Cracking**:** These cracks form a pattern similar to an alligator's skin as illustrated in Figure 1. They are the result of repetitive traffic loads or high deflections often due to wet bases or sub grades. This type of cracking can also lead to potholes and pavement disintegration. Neither crack sealing or filling can treat this type of failure. Alligator cracking can be preceded by longitudinal cracking in the wheel paths. NOT EFFICIENT

Longitudinal Cracks**:** These cracks run longitudinally along the pavement, as shown in Figure 2, and are caused by thermal stress and/or traffic loadings. They occur frequently at joints between adjacent travel lanes or between a travel lane and the shoulder, where hot mix density is lower and voids are higher. Longitudinal cracking may be associated with raveling and poor adhesion or stripping. These cracks can be treated effectively with crack sealants.

Transverse Cracks**:** These cracks occur perpendicular to the centerline of the pavement, or laydown direction, as shown in Figure 3. Transverse cracks are generally caused by thermally induced shrinkage at low temperatures. When the tensile stress due to shrinkage exceeds the tensile strength of the HMA pavement surface, cracks occur. These cracks can be effectively treated with crack sealants.

Block Cracking**:** These cracks form regular blocks (Figure 4) and are the result of age hardening of the asphalt coupled with shrinkage during cold weather. They can be effectively treated with crack sealants.

Reflection Cracking: Reflection cracks are caused by cracks or other discontinuities in an underlying pavement surface that propagate up through an overlay due to movement at the crack. They exhibit any of the crack patterns mentioned and must be treated according to the original distress mechanism. Figure 5 illustrates reflection cracking in asphalt concrete over Portland cement concrete. NOT EFFICIENT

Edge Cracking: These are crescent-shaped or fairly continuous cracks intersecting the pavement edge. They are located within 0.6 m (2 ft) of the pavement edge, adjacent to an unpaved shoulder. They include longitudinal cracks outside of the wheel path and within 0.6 m (2 ft) of the pavement edge (1). Figure 6 illustrates edge cracking. Edge cracks are caused by overloading at the edge of the pavement, shear failure or erosion in the shoulder. This type of cracking cannot always be treated effectively with crack sealants. NOT EFFICIENT

Slippage Cracks: These cracks produce a characteristic crescent shape, as shown in Figure 7. They occur when the top layer of the asphalt shears due to high deflections and a poor bond between the layers. This type of cracking cannot be treated effectively with crack sealants. NOT EFFECIENT

WHEN DO YOU USE CRACK FILL/SEAL?

- Longitudinal Cracking
- Transverse Cracking
- Block Cracking
- Edge Cracking

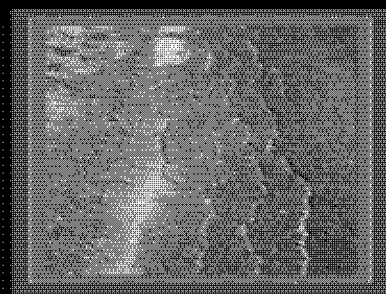
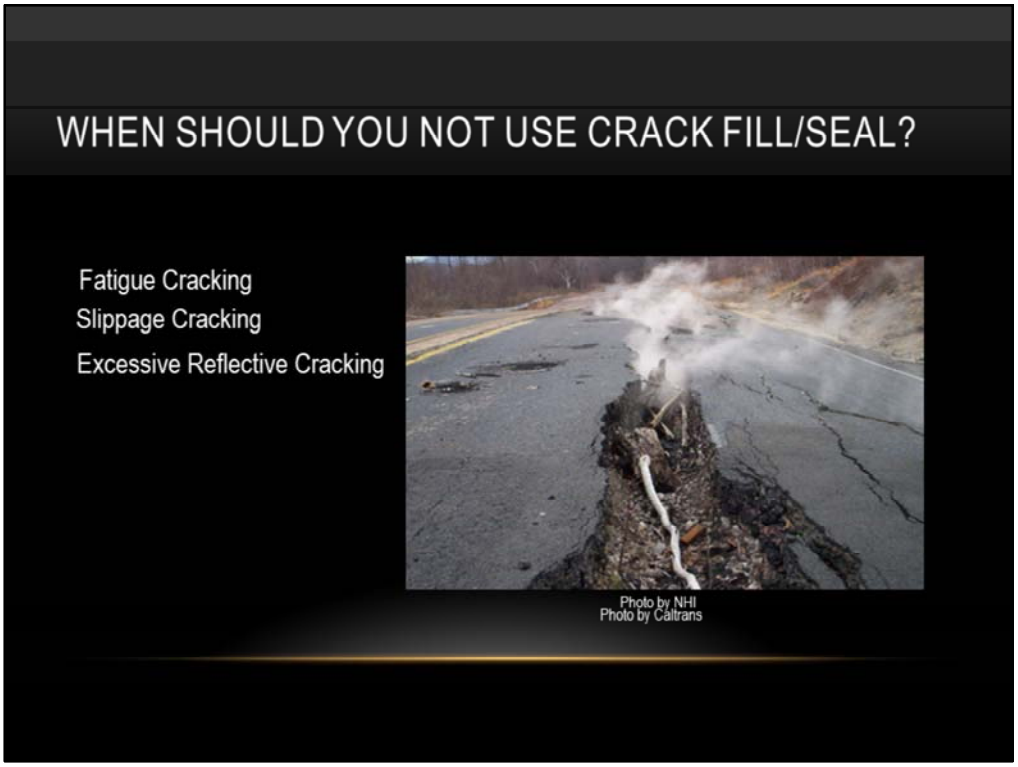
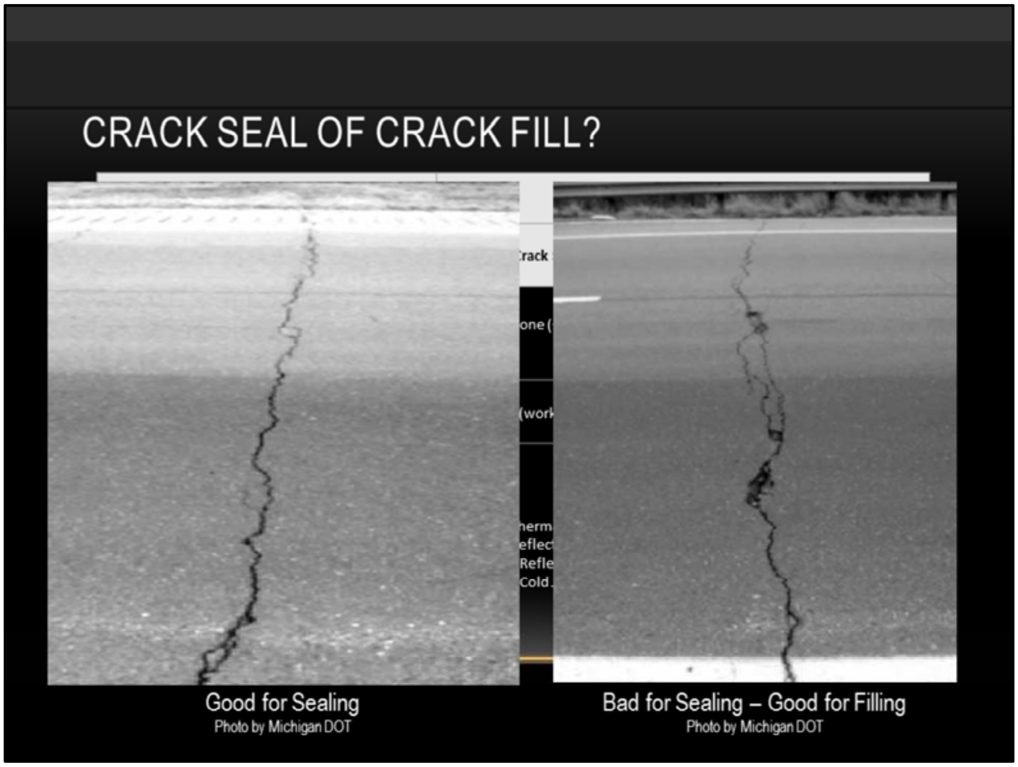


Photo by NHI



Fatigue Cracking due to poor subgrade and also due to simply fatigue failure

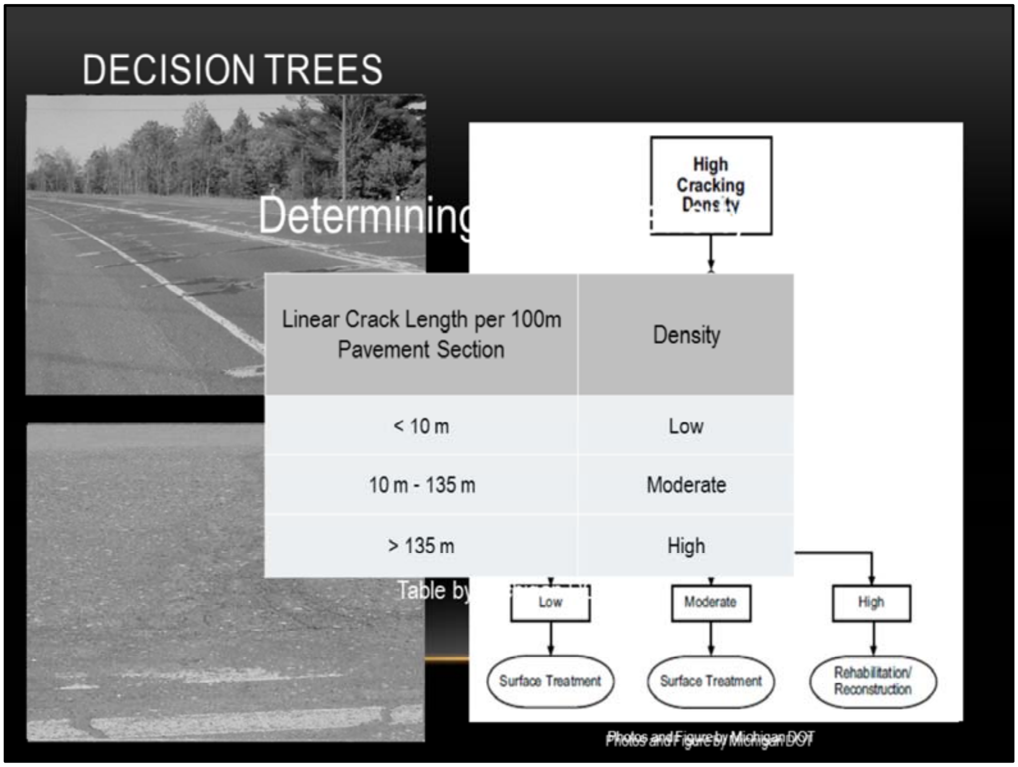


<u>Sealing</u>

- Rigorous operation, intended to prevent water from entering the pavement structure. It involves thorough crack preparation followed by the placement of a high-quality material in a specific configuration. Crack sealing is used on WORKING CRACKS, which are defined as those that experience considerable horizontal and/or vertical movement as a result of temperature changes and/or traffic loading. Working cracks typically have movements of 0.12 in.
- Cracks with a high degree of spalling and secondary cracking is not a good candidate for sealing.

<u>Filling</u>

- Activity designed to reduce the amount of water infiltration and reinforce the adjacent pavement. Cracks that experience high degree of secondary cracking and spalling are good candidates for filling.
- The cracks must not be working cracks. If they are working cracks, crack filling will not be a good option.



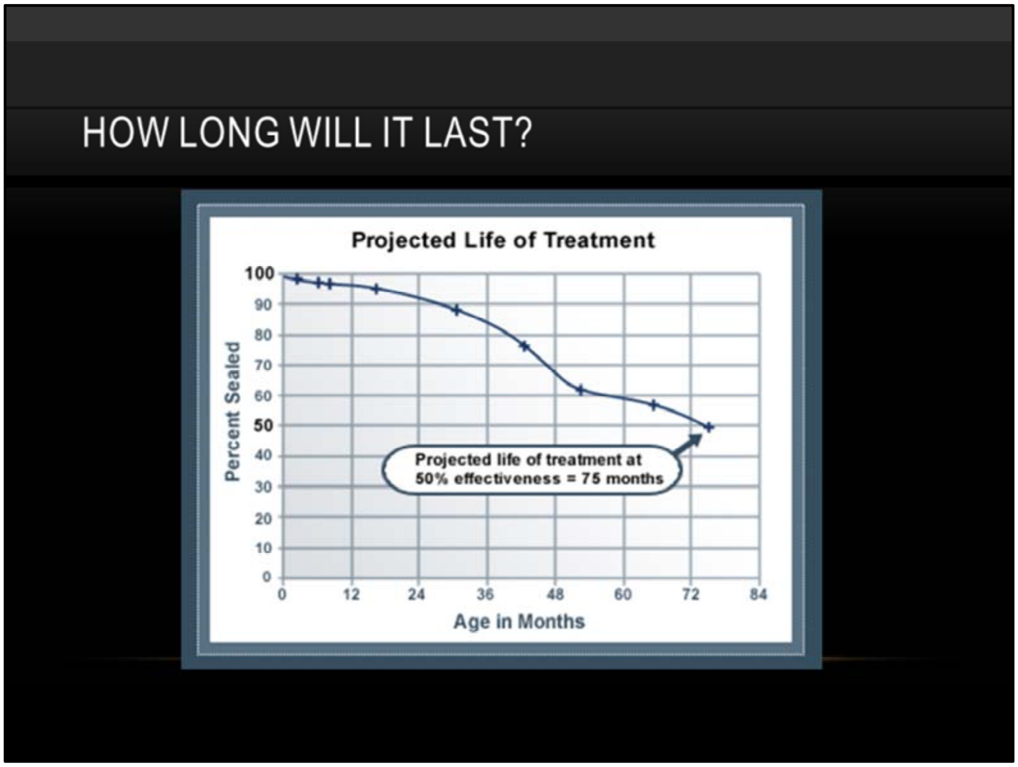
Linear Crack Length per 100m Pavement Section	Density
< 10 m	Low
10 m - 135 m	Moderate
> 135 m	High

Determining Crack Density:

- Although crack density can be determined by visual inspection, it is good to have a measure by which density is classified. In the table you can see that the length of crack per 100m is recorded and then can be classified as either low, moderate, or high density. This classification will help to determine which of the following decision trees will be used.

Decision Trees (3):

- You can see the process that is followed once the density of cracking has been determined. This decision tree aids in the process of determining not only whether crack filling or sealing should be use, but also if a crack treatment is even recommended as a treatment at all.



Asphalt Emulsion placed in flushed configuration, n unrouted cracks: 2-4 years

Hot-applied rubber and fiber modified asphalt placed in flush or overbanded configuration: 6-8 years

The first step in determining a treatment's effectiveness is to establish how much of the treatment has failed in relation to the total length of treatment applied (% failure). Once the amount of treatment failure is determined, the treatment's effectiveness can be calculated using the following expression (3).
Effectiveness = 100 - % failure……………………………………………….(2.1)
Where: % Failure = 100 X [Length of Failed Treatment / Total Length of Treatment]By routinely monitoring treated areas, a graphical representation of a treatment's effectiveness can be generated like the one shown in Figure 10. From this figure, the projected life of the treatment used on this cracked area can be projected as the time at which the effectiveness has dropped to 50% (as defined above). Graphs like these can be used to determine when additional treatments may become necessary

Crack Cutting Equipment

- Router/cutter configuration is adjusted to the required width and depth
- Make sure cutting equipment doesn't have rounded, chipped, missing, or broken teeth.

Cleaning Equipment

- Make sure air compressors have required pressure and volume
- Make sure hot air blasters/heat lancers are functioning correctly, if these are not it can be bad for the project.

Hot Applied Sealants:

- Check the melter heating, agitation, pumping systems, valves, and thermostats to ensure they are working correctly
- Make sure melter heating system is thermostatically controlled
- Make sure temperature gauges are calibrated and tested for accuracy
- Make sure proper wand tips are used

Other Application Types:

- Pumps for cold applied are functioning correctly
- Pour pots are in good working order
- Shaping and forming tools are clean and in good condition

Finishing Equipment

- With the exception of hand rollers, squeegees are the main equipment used for finishing.

Other techniques of finishing (such as sanding) does not necessarily require a special tool.

SUMMARY

- Why use Crack fill or seal?
- Types of cracks
- When should crack fill and seal be applied?
- When to use crack fill vs. crack seal
- How long will the treatment last?

Evaluations: Slurry Systems & Crack Fill/Seal

Pavement Preservation – Concepting

Evaluation Quiz

1. The definition of Pavement Preservation given in the training module is:
   a. Timely use of alternative treatments to prolong the life of the road.
   b. Use of treatments to correct road deteriorations
   c. Use of treatments to make a road structurally sound
   d. Set of procedures to fix major road deteriorations
2. T/F. Referring to the road deterioration curve, the time of application will determine whether or not it is a corrective or preventive maintenance.
3. Which of the follow is not one of the 3 R's of PM shown in the training module?
   a. Right Road
   b. Right Time
   c. Right Practice
   d. Right Treatment
4. According the training module, when selecting a road which of the following is a factor to be considered?
   a. History of the road
   b. Daily Traffic and average speed
   c. Number of lanes
   d. All of the above
   e. A & B
   f. B & C
5. A pavement with the following condition is NOT a good candidate for pavement preservation.
   a. Rutting
   b. Bleeding
   c. Oxidation
   d. Moderate to High Cracking
6. If you are surveying a road and see a pavement that looks weathered and the aggregate or binder looks to have worn away, this would be an example of which of the following distresses?
   a. Pocking
   b. Raveling
   c. Rutting
   d. Bleeding
7. According to the training module, which of the following treatments is commonly paired with seal coats to provide aggregate stability?

a. Micro surfacing
b. Fog Seal
c. Slurry Seal
d. None of the above

8. T/F. The right time to apply a pavement preservation treatment is exactly 3 years after new construction.
9. T/F. The benefits of pavement preservation can only be achieved by properly selecting and applying the right treatment on the right road at the right time.

Pavement Preservation – Design – Crack Filling and Sealing

Evaluation Quiz

1. T/F. Polymer modified emulsions can be used for filling and minor sealing and will last approximately 3 to 5 years.
2. T/F. Crack filling and sealing materials are both meant to adhere to crack walls and resist abrasion and damage, but crack sealing is meant for inactive (non-working) cracks while crack filling material is meant for moving (working) cracks.
3. __________ material should only be used for crack sealing.
   a. Asphalt Rubber
   b. Specialty AR Low Modulus
   c. Silicone
   d. All of the above
4. Which of the following methods is not recommended as it can create a rough ride, excess noise, and possible problems with future overlays?
   a. Flush Fill
   b. Reservoir
   c. Capped Overband
   d. None of the above
5. T/F. If a crack is going to filled instead of sealed, it will usually call for a reservoir method.
6. ____________ should be avoided for heavily trafficked roads?
   a. Overband Configurations
   b. Flush Fill
   c. Reservoir
   d. None of the above
7. ____________ and recessed band-aid configurations provide the longest life.
   a. Overband
   b. Flush Fill
   c. Flush Reservoir
   d. None of the above

Pavement Preservation – Design – Slurry Systems

Evaluation Quiz

1. T/F. Before materials such as emulsions and aggregate can be selected, a road must be identified and characterized as an appropriate road for a slurry system treatment.
2. When selecting an aggregate for slurry systems, which of the following does NOT need to be taken into account?
   a. Particle Shape and Charge
   b. Gradation and Particle Size Distribution
   c. Toughness and Abrasion Resistance
   d. None of the Above
3. Which of the following aggregate gradations will only be used for Slurry Seal?
   a. Type I
   b. Type II
   c. Type III
   d. Type IV
4. T/F. A micro surfacing emulsion will always be polymer modified and will break through a chemical reaction while slurry seal emulsions may or may not be polymer modified and break through water evaporation.
5. Which of the following defines the overall charge of an emulsion?
   a. Emulsifier
   b. Surfactant
   c. Both a & b.
   d. Neither a or b.
6. Which of the following are examples of mineral fillers?
   a. Aluminum Sulfate Crystals
   b. Amines
   c. Portland Cement
   d. Water
7. T/F. Although some dry additives dissolve in water, all dry additives are considered mineral fillers.
8. When developing a job mix formula ____________ is tested using three mixes cured in circula molds for 16 hours at 140°F. The mixes used are made at three emulsion contents: optimum, optimum +2%, and optimum -2%.
   a. Abrasion Resistance
   b. Cohesion Build-up
   c. Upper Binder limit
   d. None of the above

9. T/F. To find the optimum binder content the results from the Wet Track Test (TB 100) and Excess Binder Test (TB 109) are plotted on the same graph and where they intersect is the optimum binder content.
10. T/F. Slurry seal mixtures are identical to micro surfacing mixtures.

Pavement Preservation – Construction – Crack Fill/Seal

Evaluation Quiz

1. Which of the following is not in the process of construction for crack filling?
    a. Traffic Control and Safety
    b. Material Preparation
    c. Crack Cutting
    d. Crack Cleaning and Drying
2. Crack Cutting can be done with a _____________.
    a. Rotary Impact Router
    b. Diamond Blade
    c. Both a and b could be used
    d. Neither a or b should be used
3. T/F. Similar to the crack cutting step, crack cleaning is only done for cracks that will be sealed.
4. Which of the following should NOT be considered when preparing the material for placement?
    a. Minimum placement temperature
    b. Material heating temperatures
    c. Prolonged heating guidelines
    d. Recommended pavement temperature
    e. Recommended moisture conditions
    f. None of the above
5. T/F. Backer Rod Flush Finish material placement method would be considered a crack filling method.
6. T/F. When an emulsion is used a blotter coat will need to be applied prior to traffic use.

Pavement Preservation – Construction – Slurry Systems

Evaluation Quiz

1. If temperatures are around _______ degrees and raising the conditions are favorable for applying a slurry system.
    a. 40
    b. 50
    c. 100
    d. 25
2. T/F. The contractor will need to set up an area for staging that is close to the jobsite and also stays clear of material contamination.
3. T/F. When preparing a surface for a slurry system, it is o.k. to leave grease and oil spots without cleaning.
4. T/F. The surface preparation is so important because if it is not properly cleaned, the emulsion will not adhere to the existing pavement.
5. Which of the following are types of pavement markings that may need to be dealt with?
    a. Paint Markings
    b. Raised Markings
    c. Thermoplastic Markings
    d. All of the above
6. Which of the following will you NOT need to calibrate the feed rate for?
    a. Aggregate
    b. Mineral Filler
    c. Emulsified Asphalt
    d. Water
    e. Additive
    f. None of the above
7. According to part 2 of the training module aggregate gradation, surface texture, and moisture content all affect the _________ of a slurry system?
    a. Application Rates
    b. Life of pavement
    c. Set time
    d. None of the above
8. T/F.When inspecting the edge line during a slurry system application if the material is flowing onto the shoulder the mixture probably has too much water content and the operator should be stopped until the mixture is at the proper consistency.
9. T/F. When deciding whether or not a Micro-surfacing is ready to carry traffic, a good rule of thumb is that the material is ready for traffic once in has turned black.