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ASPHALT PAVEMENT SEAL COATS: Best Practices and Experience

FINAL REPORT

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16. Abstract

Sealcoating (also known as, chip seals) is one of the most commonly used pavement preventive maintenance activity for asphalt pavements, especially for low volume roadways. This study conducted a comprehensive evaluation of the current sealcoating practices across Pennsylvania through review of current literature and specifications, survey of state and local transportation entities in Pennsylvania and through series of interviews. In addition to seal-coating this study also conducted literature review and surveys on other asphalt pavement preventive maintenance activities in Pennsylvania. Using the review and current agency practices, best practices regarding sealcoating with respect to their use, application timing and, materials and construction specifications have been identified.

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Disclaimer

Impactful Resilient Infrastructure Science and Engineering (IRISE)

Asphalt Pavement Seal Coats: Best Practices and Experience

Final Report

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ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AEMA	Asphalt Emulsion Manufacturers Association
ASTM	American Society for Testing and Materials
DOT	Department of Transportation
FHWA	Federal Highway Administration
HMA	Hot Mix Asphalt
ISSA	International Slurry Surfacing Association
PPRA	Pavement Preservation and Recycling Alliance
RAP	Reclaimed Asphalt Pavement
UTBWC	Ultra-Thin Bonded Wearing Course
INDOT	Indiana DOT
NJDOT	New Jersey DOT
NYDOT	New York DOT
ODOT	Ohio DOT
PennDOT	Pennsylvania DOT
SDDOT	South Dakota DOT

SECTION 1: LITERATURE REVIEW OF SEAL COAT MATERIAL SELECTION, CONSTRUCTION, AND PERFORMANCE

This section provides a summary of a comprehensive literature review that was conducted on seal coating and other pavement preservation methods.

1.1 INTRODUCTION

This section consists of a review of best practices regarding pavement preservation material selection, construction, application cycle timing, quality assurance processes, life expectancy, and life cycle cost impacts. This literature review closely examines the following pavement preservation methods:

- Asphalt seal coat
- Asphalt fog seal for asphalt seal coat
- Asphalt surface treatment
- Slurry seal
- Polymer-modified emulsified asphalt paving system (micro-surfacing)
- Ultra-thin bonded wearing course

Throughout this section, the PennDOT specifications for the above preservation treatments are compared with specifications from other state DOT agencies, along with specifications from additional professional societies and associations. The specifications from the DOT state agencies were based on their geographical regions, as state specifications were selected only if they are in a region in which their climate is similar to that of Pennsylvania to minimize possible discrepancies in their specifications.

1.1.1 Pavement Preservation

Pavement preservation, also known as preventative maintenance and pavement rehabilitation or reconstruction, are different treatment methods used to improve the condition of pavement as well as to prolong a pavement's service life. Pavement preservation treatments are proactive techniques used to delay or prevent the degradation of a pavement structure. They are generally carried out on pavement structures in good condition, with an overall goal of keeping them in good condition for as long as possible. Performing a preservation treatment will sustain or increase the condition of the pavement (Pavement Preservation, 2023) and will generally prolong the pavement's need for more in-depth, more expensive treatments. This is due to the fact that they are generally carried out to prevent the degradation of a pavement (Pavement Preservation (When, Where, and How)). Comparatively, pavement rehabilitation or reconstruction methods are typically performed when the pavement structure is no longer in satisfactory condition, and thus, a rehabilitation or reconstruction treatment of the entire structure is performed to bring the pavement back to a satisfactory condition. If preservation treatments are not performed, the pavement condition will degrade at an increased rate, and a more costly, more significant reconstruction or rehabilitation application will be necessary. Thus, as shown in Figure 1-1, more extensive reconstruction treatments can be delayed, if not avoided, over the life of a pavement if preservation treatments are performed on the pavement.

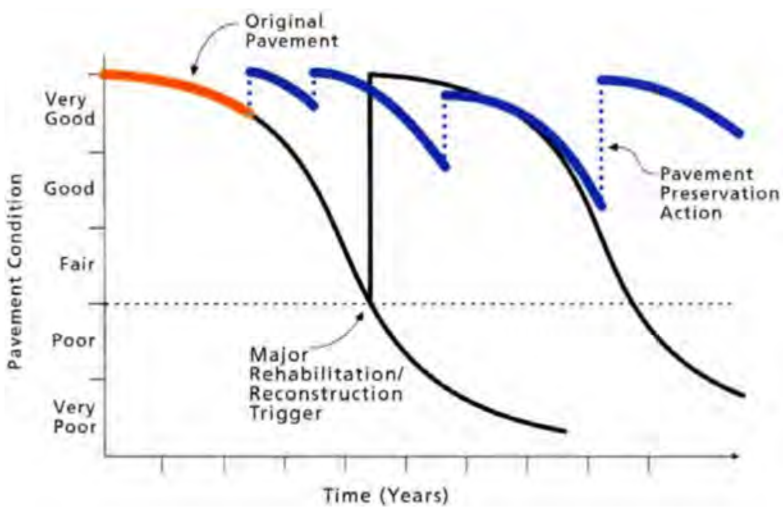

Figure 1-1 Pavement Preservation Process: A Best Practice (Pavement Preservation: A Proactive Approach, n.d.)

As displayed in Figure 1-1, preservation methods can be implemented in order to improve the condition of a pavement, prolong its degradation, and extend its overall life. Performing preservation treatments are significantly less expensive than performing major rehabilitation and reconstruction treatments, and thus continually applying preservation treatments and spending smaller amounts throughout the life of a pavement, instead of fewer times and higher amounts, can be more cost-effective for DOT agencies over time, for their pavements (Pavement Preservation: A Proactive Approach, n.d.). Further, pavement preservation treatments reduce the rate of pavement degradation and have the ability to improve ride quality, such as smoothness and friction, of the surface of the pavement. Different pavement preservation methods include applications of asphalt and in some cases, fine and/or coarse aggregate to the surface of a pavement. The application of the asphalt to the surface can prevent excess water from penetrating into the pavement structure, while the application of aggregate provides added friction and an additional layer of protection to the existing pavement surface (Pavement Preservation (When, Where and How), n.d.). Common types of pavement preservation methods include but are not limited to, single and double chip seals or seal coats, fog seals, slurry seals, scrub seals, micro-surfacing, ultra-thin bonded wearing courses, surface applied rejuvenators, asphalt surface treatments, etc.

Each of these pavement preservation methods is comprised of different processes and different materials. The type of pavement preservation treatment that an agency selects to implement on a roadway could be based on the functional class of the roadway, their prior experience with certain practices, distresses present in the existing roadway, etc. The selection process of how agencies determine which pavement preservation treatment is used on which roadways will be further examined in the agency survey distributed as part of Task B of this project.

Each pavement preservation treatment provides slightly different benefits to the pavement structure and, therefore, can be selected to treat the necessary, most prominent distresses. In the Minnesota Department of Transportation Pavement Preservation Manual, a figure is presented with recommendations for the applicability of preservation treatments to be applied, dependent on the condition of the existing pavement and the distresses and their severities present. This figure, Figure 1-2, is displayed below.

Through examining Figure 1-2, it is evident that many different preservation methods could be applicable and therefore implemented, even if the same distresses exist on different roadways. This factor (project selection and treatment type), along with differences in application timing of the treatments, materials used, and the quality of the constructions, different projects implementing the same preservation treatment regularly produce significant variation in how they perform over time.

As stated, many factors can influence the performance of each of the treatment types. Therefore, the primary focus of this study is to provide recommendations, or ‘do’s and don’ts’ based on past applications, performances, and methods of the different preservation treatment types.

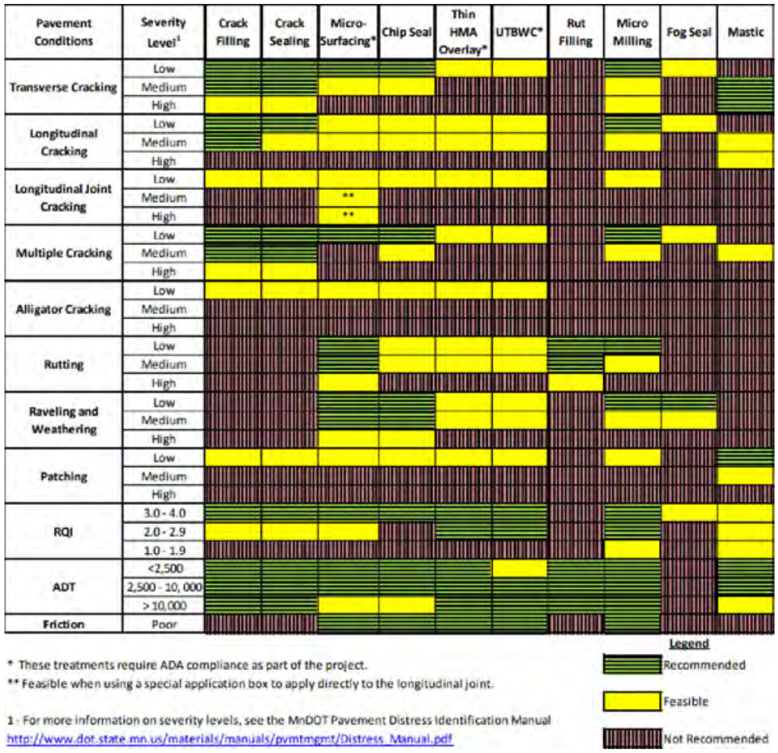

Figure 1-2 Treatment Selection Guidelines for Flexible Pavements (MnDOT Pavement Preservation Manual, 2019)

1.1.2 Pavement Preservation Methods and Definitions

Of the pavement preservation treatments mentioned above, the primary focus of this report will be surrounding seal coats, fog seals, asphalt surface treatments, slurry seals, micro surfacing, and ultra-thin bonded wearing courses. Different agencies across the United States specify similar treatment methods, using different treatment names. Thus, the following descriptions detail the definitions that will be assumed for the treatment types described throughout the remainder of this report:

- Asphalt seal coat: "the application of emulsified asphalt, immediately followed by the application of coarse aggregate" (PennDOT Publication 408/2020 - Section 470 - Asphalt Seal Coat, 2020). It is also commonly called a chip seal or oil and chip.
- Asphalt fog seal for asphalt seal coats: "the application of an asphalt seal coat with an application of asphalt material and an application of fine aggregate" (PennDOT Publication 408/2020 - Section 472 - Asphalt Fog Seal for Asphalt Seal Coats, 2020).

- Commonly, other agencies or entities consider fog seals to be solely the application of asphalt material to an existing surface (PPRA: Fog Seal Treatments, 2023).

- Asphalt surface treatment: "two applications of emulsified asphalt, with each application of emulsified asphalt, immediately followed by an application of coarse aggregate" (PennDOT Publication 408/2020 - Section 480 - Asphalt Surface Treatment, 2020). It is also commonly called a double-chip seal.
- Slurry seal: PennDOT did not define a slurry seal within their specifications, and thus, the following definition of 'slurry seal' will be assumed throughout this report: "a carefully designed mixture of asphalt emulsion (which may be polymer-modified), mineral aggregate, water, and additives; proportioned, mixed and uniformly spread over a properly prepared surface at a single stone thickness" (PPRA: Slurry Seal, 2023).
- Micro-surfacing: PennDOT did not define micro surfacing within their specifications, and thus, the following definition of 'micro surfacing' will be assumed throughout this report: "Micro surfacing consists of a carefully designed mixture of polymer-modified asphalt emulsion, mineral aggregate, water, and additives; proportioned, mixed and uniformly spread over a properly prepared surface" (PPRA Micro Surfacing Treatments, 2023).
- Ultra-thin bonded wearing course: "the construction of a polymer-modified emulsified asphalt membrane (UTFCEM – Ultra-Thin Friction Course Emulsified Asphalt) immediately overlaid with an ultra-thin bonded wearing course of hot-mix asphalt concrete (UTWC – Ultra-Thin Wearing Course) in one pass of a single paving machine" (PennDOT Publication 408/2020 - Section 489 - Ultra-Thin Bonded Wearing Course, 2020).

For comparison purposes, in this study, the PennDOT specifications will only be compared with other specifications in which their treatment method aligns with the PennDOT specification.

1.2 ASPHALT SEAL COAT

The many types of pavement preservation methods each have specific advantages, disadvantages, and methods. Thus, when determining which method would be the most beneficial for a given roadway, there are many factors to consider. The current condition of the roadway, the amount of traffic that the roadway experiences, the cost of the treatment's implementation, and the ability/availability of construction crews/equipment to perform the treatments all influence an agency's decision when selecting a treatment method. The existing condition of the roadway should be compared with each of the benefits of each preservation method and with each of the drawbacks of each method. For example, a fog seal should not be placed on a roadway that is experiencing bleeding as it could worsen and intensify that already existing distress (Pavement Preservation Checklist Series: Fog Seal, 2019). Further, each seal coating method requires different materials, equipment, and procedures, and thus, they each have different costs to implement as well. A further detailed inquiry into the project selection process and how PennDOT agencies, or other local transportation agencies, determine which preservation treatments to implement on which pavements will be examined throughout the coming tasks for this project; through the survey administered to PennDOT districts and other Pennsylvania local transportation agencies, along with the further interviews that will take place with select Pennsylvania agencies and additionally with contractors and consultants.

The main objective of Section 1.2 of this literature review is to compare PennDOT asphalt seal coating specifications with those of other agencies, entities, and organizations. The following PennDOT specifications will be evaluated through this section:

- Section 470: Asphalt seal coat
- Section 471: Asphalt seal coat using precoated aggregate
- Section 472: Asphalt fog seal for asphalt seal coats
- Section 473: Asphalt seal coat using aggregate from RAP

Section 480: Asphalt surface treatment

- Section 481: Asphalt surface treatment using precoated aggregate

The primary focus points for comparison of the specifications listed above are the materials used for each seal coating technique, the timing of the application of the treatments, and the quality of the construction of the treatment applications. Additional pavement preservation methods and PennDOT specifications, such as for slurry sealing, micro surfacing, and applying ultra-thin bonded wearing courses, will be examined in Section 3 below.

1.2.1 Asphalt Seal Coat

As discussed in Section 1.1, as defined by PennDOT, seal coating is "the application of emulsified asphalt material, immediately followed by the application of coarse aggregate." In a seal coat application, after the asphalt and aggregate application, the surface is rolled to embed the aggregates in the asphalt material, as displayed in Figure 1-3 below.

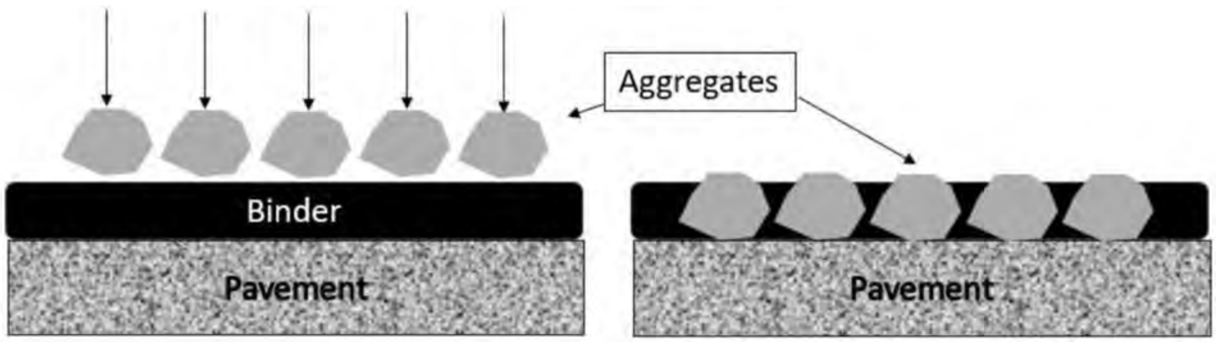

Figure 1-3 Seal Coat Application Diagram (Ali, Mehta, & Shackil, 2020)

In this section, the PennDOT Section 470 Asphalt Seal Coat Specification (PennDOT Publication 408/2020 - Section 470 - Asphalt Seal Coat, 2020) will be compared with the equivalent specifications from the Indiana DOT (INDOT Standard Specifications Section 404 - Seal Coat, 2024), Ohio DOT (ODOT Construction and Material Specifications Item 422 Chip Seal, 2023), South Dakota DOT (SDDOT Standard Specifications for Roads and Bridges Section 360 - Asphalt Surface Treatment, 2015), New York DOT (NYDOT Standard Specifications Section 410 - Chip Seal, 2016), FHWA (FHWA Standard Specifications for Construction of Roads and Bridges Section 407 - Chip Seal), and ISSA specification (ISSA A165 Recommended Performance Guideline For Chip Seal, 2012), along with the PPRA (PPRA Chip Seal Treatment, 2023) and AEMA recommendations (AEMA: Asphalt Emulsions and Their Role in Chip Seal Application as a Pavement Maintenance Technique, n.d.). The PennDOT Asphalt Seal Coating Specification details the material selection requirements, the required steps for preparing the surface of the existing pavement before applying a seal coat, the process of the application of the emulsified asphalt material, the application, spreading, and rolling of the coarse aggregate material, the steps required after the application is complete to protect the surface of the seal coat until curing is completed, and lastly the steps required to evaluate the completed seal coat by the state or district representative. The project selection aspect of when PennDOT agencies should elect to implement an asphalt seal coating treatment to pavement is not discussed in this specification. This specification details the process of implementing the treatment, after it has already been selected as the proper treatment method.

1.2.1.1 Materials for an Asphalt Seal Coat

Two materials are required in a seal coating application: asphalt material and coarse aggregate. This section will detail the requirements that different specifications detail in terms of the properties and characteristics of the materials to be used in an asphalt seal coat application.

Seal Coat: Emulsified Asphalt Material

As per the PennDOT seal coat specification, the asphalt material used in a seal coat project is required to be emulsified asphalt. Table 1-1 below lists the different types of emulsified asphalt that PennDOT specifies can be used in a seal coating application.

Table 1-1 Emulsified Asphalt Materials for Seal Coating Applications (PennDOT Publication 408/2020 - Section 470 - Asphalt Seal Coat, 2020)

Class of Material	Type of Material
RS-2PM	Polymer-Modified Emulsified Asphalt
CRS-2PM	Polymer-Modified Cationic Emulsified Asphalt
HFRS-2PM	Polymer-Modified High Float Emulsified Asphalt
RS-2	Emulsified Asphalt
CRS-2	Cationic Emulsified Asphalt
HFRS-2	High-Float Emulsified Asphalt

In addition to specifying the list above, the PennDOT Asphalt Seal Coat specification also notes that each of these emulsion types should be between 140^{0}F and 175^{0}F during their application. It further states that written approval must be obtained prior to construction if the emulsified asphalt being used is not polymer-modified, as the polymer-modification can significantly improve the initial and long-term performance of the seal coat, and therefore non-polymer-modified emulsified asphalt would likely only be used for seal coats being applied to low volume roadways (Kim & Im, 2015). In some of the other seal coating specifications evaluated in this report, in place of emulsified asphalt, hot asphalt concrete is also an allowable material to be used. Using the emulsified asphalt allows for energy savings as the emulsified asphalt can be sprayed on the surface at significantly lower temperatures than hot asphalt concrete can be. Table 1-2 below presents the specified allowable asphalt materials to be used for the application of a seal coat for different agencies and entities.

Table 1-2 Allowable Asphalt Materials in Seal Coating Applications

Specification	Types of Asphalt Material for Use in a Seal Coat
PennDOT	RS-2PM, CRS-2PM, HFRS-2PM, RS-2, CRS-2, HFRS-2

INDOT	Emulsified asphalt, RS-2, AE-90, AE-90S, or HFRS-2
ODOT	Polymer emulsified binder
FHWA	Asphalt binder or emulsified asphalt
PPRA	Hot asphalt cement or emulsified asphalt
ISSA	Asphalt or emulsified asphalt

As made evident by the table above, some of the specifications and recommendations allow for the use of either emulsified asphalt or hot asphalt cement in an asphalt seal coat application. Performances of seal coats in the Atlanta District of Texas using emulsified asphalt versus hot asphalt cement were compared in a study, and these applications showed that the seal coats constructed with emulsified asphalt material had performances similar to those constructed with hot asphalt cement (Gransberg & Zaman, 2005). It is notable that in Table 1-2 above, the three state DOT specifications that were evaluated all specified the use of emulsified asphalt binder, while the FHWA, PPRA, and ISSA, the organizations, recommendations, or specifications noted that either hot asphalt cement or emulsified asphalt binder could be used for the application of an asphalt seal coat.

The process of Pennsylvania agencies or contractors to select which type of emulsified asphalt material to use in the application of an asphalt seal coat has not been reported significantly. An evaluation of this process and selection will take place throughout the coming tasks for this project; through the survey administered to PennDOT districts and other Pennsylvania local transportation agencies, along with the further interviews that will take place with select Pennsylvania agencies and additionally with contractors and consultants.

As displayed in the table above, requiring the asphalt material used in a seal coating operation to be polymer-modified is not specified by all of the state specifications evaluated in this study. As discussed according to the PennDOT specification, in Pennsylvania, using a non-polymer modified emulsion requires written approval prior to construction. The benefits of using polymers in asphalt material are increased resistance to temperature damage in the asphalt, along with improved adhesion (Johnston & King, 2008) (Aktas & Karasahin, 2013).

Seal Coat: Coarse Aggregate

The coarse aggregate used in a seal coat application is one of the crucial pieces to ensure optimal performance of the seal coat. The coarse aggregate used must be compatible with the asphalt material used, and by the method of spreading and rolling it on the asphalt surface within adequate timing and with adequate pressure and passes to ensure that the aggregate is properly embedded in the asphalt so that it does not come loose due to the traffic loading that it will experience.

In addition to its compatibility with the asphalt material used, the gradation of the aggregate, along with the shape of the aggregate used in a seal coating application, is also important to ensure the treatment achieves optimal performance. Coarse aggregate is used in seal coating applications to improve the friction and the ride quality of the surface of the pavement. By examining the specifications, it was found that different states allow for slightly different coarse aggregate required characteristics to be used in seal coat applications. The ISSA specification recommends that one-sized coarse aggregate with 100% angular faces is used for the best performance of the seal coat. The ISSA specification also states that the ratio of flat and elongated particles should have a ratio of 3:1 (ASTM D 4791), which is the same ratio that the PennDOT seal coating specification states. As stated, the ISSA specification also notes that the aggregates should have 100% fractured face (AASHTO T 335 or ASTM D 5821), while the PennDOT specification does not specify this characteristic. Lastly the ISSA specification states that the coarse aggregate should have a maximum resistance to degradation in the Los Angeles Machine of 25% (AASHTO T 96 or ASTM C 131), whereas the PennDOT specification does not specify this property requirement for the aggregate used in a seal coat application either. The allowable gradations of the coarse aggregate used in a seal coating application varied slightly from specification to specification. Overall, like in the PennDOT specification, it was recommended that one-sized coarse aggregate was used and that the total percent passing the No. 200 sieve was not more than 1%.

1.2.1.2 Construction of an Asphalt Seal Coat

In addition to the materials selected to be used for a seal coating application, the construction of the treatment also plays a large part in the overall performance of the treatment (Gurer, Karasahin, Cetin, & Aktas, 2012). Factors such as the application timing along with the material application rates, the amount of rolling that is performed, the traffic control put in place to protect the surface after its application, and the quality assurance and quality control practices contribute greatly to the overall performance of the seal coat.

Seal Coat: Preparation of Existing Surface

Preparing the surface of the existing pavement structure, on which a seal coat is being applied, to be in sufficient condition to receive the seal coat application is the first step in the physical construction process. It was stated in the PennDOT specification, along with the other specifications evaluated, that before applying a seal coating treatment, the surface of the pavement should be cleared of loose material or debris that exists on the surface, and it should also be dried, to ensure that there is no excess water present. These two steps ensure proper adhesion of the asphalt material to the surface. In some cases, cracks on the existing surface are also sealed before applying the seal coat in an effort to avoid reflective cracking from occurring from the existing pavement through the seal coat. Some states also specify that before seal coating, areas requiring patching are patched, further assisting in improving the life expectancy of the seal coat. The PennDOT specification states that before seal coating, existing cracks on the surface should be sealed. Some differences noted between the PennDOT seal coat specification and other agency or entity specifications are that in the INDOT, SDDOT, and NYDOT specifications, for example, they note that the coverage of all structures (such as manhole covers, catch basins, etc.) must be coved each day during seal coat construction by the contractor, whereas the PennDOT specification does not. Further, as per the PPRA recommendations, the sealing of cracks should be performed at least 3 months prior to applying a seal coat to the surface, and similarly, areas that require patching should be patched at least 6 months prior to applying a seal coat to the surface. The PennDOT specification does not specify the amount of time between performing these other treatments and performing the seal coating application.

Seal Coat: Application of Emulsified Asphalt

After the surface is prepared, the second step in the physical construction process is to apply the asphalt material to the pavement surface. Because of the nature of the asphalt material, the air and, therefore, the pavement temperature at the time of the application has a substantial impact on the performance of the seal coat and how it cures. Many states, including Pennsylvania, specify minimum (and in some cases maximum) temperatures of the air and/or of the pavement surface to allow for the application of a seal coat to ensure proper curing of the asphalt material. Ensuring that the seal coat is being applied while the pavement temperature is within an appropriate temperature range also assists in allowing the aggregate to become properly embedded in the asphalt material, as applying the asphalt material when the surface is too cold will accelerate its hardening process and curing timing, possibly preventing full embedment of the aggregate. In addition to setting temperature requirements for applications, many specifications also specify the earliest date and last date in the calendar year, generally dependent on the geographic location for which seal coats are able to be applied. As shown in Table 1-3, PennDOT specifies that seal coats should be applied when the air, pavement, and aggregate temperatures are all at a minimum of 60°F and states that they should only be applied between May 1st and September 15th or October 1st (dependent on the district or location in Pennsylvania that the project is taking place). Requiring the minimum air and pavement temperature for seal coating applications to be at 60°F is similar to that of many of the other state agency specifications examined in this study, although some states, such as Ohio DOT and South Dakota DOT, specify a minimum air temperature of 70°F. Further, the state specifications selected to be evaluated through this study were selected because they have climates relatively similar to that of Pennsylvania and thus would be suitable for comparison. Most of the specifications also state the earliest date of the year that seal coats are able to be applied in their area as May 1st, with South Dakota only allowing seal coat applications beginning May 15th. The end of the allowable time of year for asphalt seal coats to be applied ranged from August 31st to October 1st, depending on the state. Because the other organization specifications (such as FHWA, PPRA, and ISSA) are not specifications for specific locations, they note minimum temperatures for applications, but did not specify specific allowable dates of application.

Table 1-3 Seal Coat Application Weather Limitations

	Min. Air Temp. (°F)	Min. Pavement Temp. (°F)	Earliest Date	Latest Date
PennDOT	60°F	60°F	May 1st	September 15th or October 1st
INDOT	60°F	60°F	May 1st	October 1st
ODOT	70°F	60°F	May 1st	September 15th
SDDOT	70°F	70°F	May 15th	August 31st or September 15th
NYDOT	50°F	60°F	May 1st	September 7th
FHWA	65°F	60°F	---	---
PPRA	60°F (if emulsion) 70°F (if AC)	60°F (if emulsion) 70°F (if AC)	---	---
ISSA	60°F	60°F	---	---

In addition to the minimum allowable temperatures and the permitted date windows for applying asphalt seal coats, some of the agency or entity specifications noted additional weather conditions that are required to be satisfied as well to construct a seal coat. PennDOT specified, as the FHWA recommend, that seal coats should not be performed on a day in which rain or freezing temperatures are expected within 24 hours of the application. Further, the FHWA recommended that during an asphalt seal coat application, there should not be fog or rain, as the additional water could impact the curing or bonding and, therefore overall performance of the seal coat, and also recommended that the wind at the time of application is less than 10 miles per hour, as higher winds could impact the application of the asphalt material that gets sprayed onto the surface. The FHWA also recommends that seal coat construction should be applied and completed at a minimum, 2 hours before the sun sets to allow for complete curing of the material. Lastly, the FHWA also recommended that seal coats not be applied when the temperature of the pavement surface was above 150°F. The maximum temperature of the application was not specified in the PennDOT specification.

As specified by PennDOT and many of the other specifications examined, the application of the asphalt material in a seal coating treatment is performed by a distributor that is capable of spraying the emulsified asphalt uniformly over the surface. The rate of the application is determined in different methods, depending on the agency that is implementing the seal coat. An additional step of the asphalt material application process that was not specified in the PennDOT specification was the method used to ensure uniform coverage over the surface, when the spray has to be started or stopped. In the FHWA recommendations, it is recommended to use a control strip to begin a seal coating application, in addition to using a control strip when continuing a seal coating application after a pause.

Seal Coat: Spreading and Rolling Coarse Aggregate

After the asphalt material is applied to the surface, the coarse aggregate is spread on top of it, and then it is rolled. The amount of time between the asphalt application and the aggregate application, or the aggregate application/spreading and the surface rolling varies slightly depending on the state or entity specification. The number of required rolling passes, as well as the type of roller to be used, can also vary when it comes to seal coats.

Spreading of Coarse Aggregate for Seal Coat Applications:

The PennDOT specification, along with the South Dakota, FHWA, and ISSA specifications, state that the coarse aggregate should be spread on the asphalt material immediately after its application. Indiana DOT states that the aggregate should be spread on the asphalt material within one minute of the asphalt's application. Many of the specifications, such as Indiana DOT, New York DOT, FHWA, and ISSA, note that the equipment used to spread or apply the coarse aggregate should not come into contact with the freshly applied asphalt material until the aggregate has been spread on the surface. This prevents the tires of the equipment from picking up and tracking the asphalt material before the aggregate has been placed. Some of the examined specifications, such as the Ohio DOT, noted that the aggregate spreader must be spreading the aggregate on the surface within 150 feet of the distributor applying the asphalt material to the surface.

Rolling Coarse Aggregate in Seal Coat Applications:

The PennDOT specification, along with the other specifications evaluated in this study, stated that pneumatic tire rollers should be used to roll the coarse aggregate and embed it into the asphalt material during a seal coating application. As per the PennDOT seal coat specification, this rolling of a newly applied seal coat is to be commenced within 5 minutes of the spreading of the asphalt material to the surface. The recommended amount of time between the spreading and rolling of the coarse aggregate varied depending on the specification. As stated, PennDOT specified that the time between the spreading and the rolling of the coarse aggregate during a seal coating application should be less than 5 minutes, which is the same amount of time specified by the Ohio DOT and the NYDOT. Comparatively, the INDOT specified that rolling should be commenced within 2 minutes and completed within 30 minutes of the spreading of the aggregate. The PPRA and ISSA recommendations did not state a maximum amount of time between spreading and rolling, but both recommended that the rolling should happen just after the spreading. During the rolling process, the PennDOT specification, along with the ISSA specification, stated that the roller should not travel at speeds greater than 10 miles per hour to ensure that the roller does not displace the newly applied aggregate. Comparatively, the Ohio DOT, SDDOT, NYDOT, and FHWA recommended that the rollers should not travel at speeds greater than 5 miles per hour, for the same reason.

The required contact pressure of the rollers used in a seal coating application, along with the minimum number of passes, was also noted in many of the specifications evaluated. In the PennDOT specification, it was noted that the rollers should have a contact pressure of 40-50psi, whereas the Ohio DOT and NYDOT specified that the rollers should have a minimum contact pressure of 80psi. Further, the PennDOT specification stated a minimum of 2 roller passes, while the Ohio DOT specified a minimum of 4 passes, and the NYDOT specified a minimum of 3 passes. All of the other specifications evaluated from the INDOT, SDDOT, FHWA, and ISSA also specified a minimum number of 3-4 roller passes.

Seal Coat: Protection and Surface

After the asphalt material and aggregate have been applied to the surface and then rolled to improve the embeddedness of the aggregate in the binder, the traffic on a freshly seal coated surface is usually controlled until the application has had sufficient time to cure. The PennDOT specification states that pilot vehicles and flaggers should be used to control traffic and prevent movement of the aggregate before the seal coating application is sufficiently cured but does not specify the time frame of how long a seal coating application should have to cure or at what speed traffic should travel over the surface while the treatment is curing. Comparatively, the NYDOT specification states that vehicles should not travel over 15 miles per hour over the seal coated surface during the first 3 hours after its application. Similarly, the Ohio DOT specification states that pilot vehicles should be used to maintain traffic at a speed of less than 25 miles per hour within the workday of the seal coat application. PennDOT, along with many of the other specifications evaluated, noted that sweeping may be required after rolling and/or after opening the road to traffic to remove aggregate that remained loose on the surface of the pavement.

Seal Coat: Evaluation of Completed Seal Coat Surface

The final step of an asphalt seal coating application is the evaluation of the completed seal coat surface. Throughout the process of construction, agencies and contractors have various methods in place to ensure that the quality of the construction is controlled by the construction crews. The quality assurance process is generally performed by a representative from the agency that is implementing the seal coat application. According to the PennDOT specification, it is required that a representative from the agency inspect the seal coated surface one day after sweeping is completed to ensure that at least 50% of the aggregate is embedded in the asphalt material. This specification also states that if at least 50% of the aggregate is not embedded in the asphalt material, then a fog seal may be required on the seal coated surface (see Section 1.2.6). The PennDOT specification does not specify how the representative is to determine the percent embedment of the seal coat application, but the PPRA recommends that the Sand Patch Test is performed after the construction is completed to evaluate this parameter. The post-construction evaluation of a seal coated surface by Pennsylvania agencies and entities will be evaluated through the upcoming tasks of this project.

1.2.2 Asphalt Seal Coat using Aggregate from RAP

Using recycled asphalt pavement (RAP) has become increasingly popular among agencies across the United States. The increased use of RAP in pavement applications allows for cost savings for agencies as it requires a reduction in virgin materials that need to be purchased, along with providing environmental benefits as the recycling of previous pavements allows for the reduction of the use of additional raw materials (Azzam, Kim, Rahmani, & Hu, 2020). In addition to using RAP to repave a roadway, RAP can also be used in preservation treatments such as in seal coating treatments, in place of using virgin coarse aggregate. A case study with the U.S. DOT FHWA, New Mexico DOT, and the University of New Mexico found using RAP in seal coating applications similarly beneficial to using virgin coarse aggregate in the applications (Duncan, Sibaja, Seeds, & Peshkin, 2020). Similarly, a different study found that when the mix design and construction are both adequately performed, that a seal coat application using RAP can provide equivalent benefits to a seal coating application using virgin coarse aggregate (Robbins, et al., 2021). PennDOT Specification Section 473 specifically outlines their requirements for using RAP in seal coating applications (PennDOT Publication 408/2020 - Section 473 - Asphalt Seal Coat using Aggregate from RAP, 2020). The specification is similar to that of a seal coat application using virgin aggregate. The allowable emulsified asphalt materials are the same and should be applied at the same temperatures as those detailed in the sections above.

When using RAP in a seal coating application, the RAP should have a similarly one-sized gradation, as shown in Table 1-4 below:

Table 1-4 Gradation Requirements of Seal Coat Aggregate from RAP (PennDOT Spec Section 473)

Sieve Size	% Passing by Weight
12.5 mm (1/2 inch)	100
9.5 mm (3/8 inch)	85-100
4.75 mm (No. 4)	0-30
2.36 mm (No. 8)	0-15
1.18 mm (No. 16)	0-10
75µm (No. 200)	0-1

Further, as per the PennDOT specification, there are slightly different quality control requirements to ensure the proper material properties, stating that when using RAP, its gradation should be tested for every 1,000 tons of RAP used in the application. This specification also states that seal coats using RAP as coarse aggregate are primarily used on roadways with an ADT of less than 1,000 vehicles. Written approval must be obtained to apply a seal coat with RAP on roadways with ADT between 1,000 and 5,000 vehicles, and seal coats with RAP are specified not to be applied on roadways with an ADT greater than 5,000 vehicles. One other difference between the applications of seal coats using virgin aggregate compared to when using RAP is that PennDOT specifies that a seal coat with RAP can only be applied if the surface temperature of the existing pavement is less than 120^0F, while PennDOT does not specify that there is a maximum temperature at which seal coats using virgin aggregates can be applied. This is likely due to the fact that the existing binder coating of the recycled aggregates could change properties if overheated. Many of the other specifications evaluated in this study did not cite specifications on how to perform or what materials to use in seal coating applications using RAP.

1.2.3 Asphalt Surface Treatment

As per the PennDOT treatment descriptions, an asphalt surface treatment is, in short, a double seal coat, also commonly called a double chip seal. The PennDOT specification describes this pavement preservation method as "two applications of emulsified asphalt, with each application of emulsified asphalt immediately followed by an application of coarse aggregate." Because of this, the specification for this treatment method, according to PennDOT, is very similar to that of the PennDOT Asphalt Seal Coat specification outlined in the sections above. Despite that, this section will discuss the PennDOT Asphalt Surface Treatment specification (PennDOT Publication 408/2020 - Section 480 - Asphalt Surface Treatment, 2020).

1.2.3.1 Asphalt Surface Treatment Materials

In parallel to the asphalt seal coat, the asphalt surface treatment requires the two primary materials of asphalt binder and coarse aggregates. As per the PennDOT specifications, an asphalt surface treatment is a double application of the seal coat. This would be used generally in cases in which increased durability, waterproofing, and sealing are required for a roadway (PPRA Chip Seal Treatment, 2023). The materials and construction process as per the PennDOT specification are similar to that of a seal coat in terms of the emulsified asphalt and aggregates used, along with the preparation of the surface before applying the asphalt surface treatment and the specifications for protecting the surface of the pavement after the application of the asphalt surface treatment.

1.2.3.2 Asphalt Surface Treatment Construction

Although the materials used in a seal coat and surface treatment are very similar, there are a few differences in the construction processes as per the PennDOT specifications. The PennDOT specification for an asphalt surface treatment specifies application rates and rolling pressures for each of the two applications. The specification notes that the first application should have the emulsion applied at 0.25-0.5 gallons per yard squared and the second application of emulsion applied at 0.25-0.5 gallons per yard squared as well. Similarly, the Ohio Department of Transportation specified that during an asphalt surface treatment, the emulsion should be applied to the surface at a rate of 0.34 gallons per yard squared, while the second application should be at a rate of 0.37 gallons per yard squared (ODOT Construction and Material Specifications Item 422 Chip Seal, 2023). Further, the PennDOT specification states that the aggregate for the first layer of the surface treatment should be applied to the surface at 25-45 pounds per yard squared (No. 67 coarse aggregate), while the second layer should have the aggregate applied at 15-30 pounds per yard squared (No. 8 coarse aggregate). The PennDOT specification further details that after the first application of the emulsion and the aggregates, it should be rolled, swept, and cured before the second application is applied.

1.2.4 Asphalt Seal Coat and Surface Treatment using Precoated Aggregate

PennDOT has a specification section detailing the materials and construction process of an asphalt seal coat (PennDOT Publication 408/2020 - Section 471 - Asphalt Seal Coat using Precoated Aggregate, 2020) and of an asphalt surface treatment using precoated aggregate (PennDOT Publication 408/2020 - Section 481 - Asphalt Surface Treatment using Precoated Aggregate, 2020).

PennDOT Specification Section 471 details the materials and construction necessary to perform an asphalt seal coat using precoated aggregate. Precoated aggregate is primarily used in seal coating applications to increase the compatibility between the asphalt material and the aggregates (Lopez, et al., 2022). The PennDOT specification for asphalt seal coats using precoated aggregates states that the aggregate used should meet the same gradation and other property requirements as those used for a seal coating application using non-precoated aggregates, as specified in Section 1.1.1.2 above. Similarly, the construction processes of applying a seal coat using precoated or non-precoated aggregate are identical, other than the additional requirement of the precoating process. Thus, this section will discuss the precoating materials to be used in these surface sealing applications.

As per the PennDOT specification, the precoating of the aggregate is able to be performed using cut-back asphalt (MC-30 or MC-70), emulsified asphalt (SS-1h (E-8A) or CSS-1h (E-8C)), or asphalt cement (PG 64S-22 or PG 58S-28). The specification specifically states that asphalt cement should be used to precoat the aggregates only if the precoating is performed to satisfaction. In addition, it states that cut-back asphalt should be used to precoat the aggregates only if the precoated aggregates are able to cure sufficiently before their use in the surface treatment. In a report by Kandhal and Motter titled *'Criteria for Accepting Precoated Aggregates for Seal Coats and Surface Treatments'*, it is concluded that asphalt cement AC-20 be used as a precoating material over cutback asphalts MC-30 or MC-70 due to requiring no curing with increased retention of aggregate (Kandhal & Motter). Once the aggregates have been sufficiently precoated and have been cured as required, and once the asphalt material for the seal coat or surface treatment has been applied to the surface, the precoated aggregates are then distributed over the surface. The remainder of the construction process is thereafter the same as for an asphalt seal coat or asphalt surface treatment that does not use precoated aggregate. It is also notable that the allowable asphalt materials to be used to apply to the surface during a seal coat or surface treatment using precoated aggregates are emulsified asphalt (RS-2 (E-2)), cationic emulsified asphalt (CRS-2 (E-3)), or asphalt cement (PG 46S-40). However, the specification also states that the hot asphalt cement (PG 46S-40) should only be used on the shoulders of the pavement.

When using precoated aggregate in a seal coat application, as per the PennDOT specification, all other aspects of the construction match those detailed in previous sections; application of an asphalt seal coat or asphalt surface treatment using non precoated materials.

1.2.5 Asphalt Fog Seal for Asphalt Seal Coats

As described in the PennDOT Specification Section 472: Asphalt Fog Seal for Asphalt Seal Coats, an asphalt fog seal is "the treatment of an asphalt seal coat with an application of asphalt material and an application of fine aggregate." It is stated in the PennDOT Specification Section 470 that an asphalt fog seal on an asphalt seal coat may be required if at least 50% of the coarse aggregate is not embedded in the asphalt material after the completion of the seal coat application.

Of the specifications from DOT agencies and other entities in this study, few discussed the requirements to implement when applying a fog seal onto the surface of a pavement that had recently received a seal coat; many detailed the materials and construction processes for fog seals as independent pavement preservation treatments. Thus, the PennDOT asphalt fog seal for asphalt seal coat specification will be compared with the NYDOT specification detailing a fog seal application onto a seal coat application, which was described as an application of emulsified asphalt followed by the application of fine aggregate. The PennDOT specification will also be compared with the ISSA specification, but it is noteworthy that this specification details the application of a 'fog seal' on top of a seal coat, describing the fog seal as the application of emulsified asphalt to the seal coat, and no fine aggregate.

1.2.5.1 Materials for an Asphalt Fog Seal

The materials required for an asphalt fog seal are asphalt material and fine aggregate, which can also be referred to as cover sand. The PennDOT specification states that emulsified asphalt should be used in fog seal applications but that it can be cationic or anionic and polymer-modified or non-polymer-modified. The specification further details that if cationic emulsion was used in the seal coating application, then cationic emulsion should be used in the fog sealing application, or if anionic emulsion was used in the seal coating application, then anionic emulsion should be used in the fog sealing application. The PennDOT specification also states that the emulsion should be diluted with 1 part emulsion to 1 part water, and the fog seal should be applied to the surface within 48 hours of the dilution of the emulsion. The NYDOT also specifies that diluted emulsified asphalt should be used for fog seal applications. Similarly, the ISSA specification recommends that polymer-modified emulsified asphalt is diluted 40% with water in fog sealing applications. The PennDOT and NYDOT specifications noted that after the application of the diluted emulsified asphalt to the surface, the fine aggregate cover sand can be applied to the surface. The construction processes of the applications of the asphalt material and fine aggregate are detailed in the sections below.

1.2.5.2 Construction of an Asphalt Fog Seal

As discussed, per the PennDOT specification, the fog seal is comprised of the application of emulsified asphalt followed by the application of fine aggregate to an existing pavement surface. The PennDOT specification states that the emulsified asphalt should be applied to the surface at a rate of 0.1 to 0.2 gallons per yard squared, the NYDOT specification noted an asphalt application rate of 0.05 to 0.15 gallons per yard squared, and lastly, the ISSA specification recommended an asphalt application rate of 0.08 to 0.12 gallons per yard squared. Further, both the PennDOT and NYDOT specifications recommend that within 5 minutes after the application of the asphalt, the fine aggregate should be applied to the pavement surface at a rate of 2 to 5 pounds per yard squared. The PennDOT specification further states that fog seals cure in approximately 2 hours, but both the PennDOT and NYDOT specifications state that fog seal applications should be examined and fully cured before opening to traffic. Further inquiries into current practices in Pennsylvania in terms of their protection of a newly fog sealed pavement will be examined through the future tasks of this project.

1.3 ADDITIONAL (NON SEAL COAT) PAVEMENT PRESERVATION METHODS

The main objective of Section 1.3 of this literature review is to compare additional PennDOT pavement preservation specifications with those of other agencies, entities, and organizations. The following PennDOT specifications will be evaluated through this section:

- Section 482: Slurry seal
- Section 483: Polymer-modified emulsified asphalt paving system (micro-surfacing)
- Section 489: Ultra-thin bonded wearing course

The primary focus points for comparison of the specifications listed above are the materials used for each preservation technique, the timing of the application of the treatments, and the quality of the construction of the treatment applications.

1.3.1 Slurry Seal

A slurry seal is a mixture of emulsified asphalt, fine aggregate, filler, and water applied to the surface of an existing pavement. The slurry mixture is to be homogeneous before its application to the surface. There are three types of slurry seals, dependent on the gradation of the aggregate used in the mixture. The three slurry sealing types (Types I, II, and III) increase with gradation and generally with the rate of application and are therefore selected dependent on the traffic level that the existing pavement experiences, along with the severity of existing distresses on the surface of the pavement (Slurry Seals, n.d.). Slurry seals can be used to correct surface distresses and provide increased skid resistance to the surface, along with improved protection of underlying layers of the structure.

The PennDOT slurry seal specification (PennDOT Publication 408/2020 - Section 482 - Slurry Seal, 2020) was compared with the ASTM D3910 specification (ASTM International Designation: D3910-21), along with the ISSA A105 specification (ISSA A105 Recommended Performance Guideline for Emulsified Asphalt Slurry Seal).

1.3.1.1 Materials for a Slurry Seal

The materials that are generally used in slurry seals are asphalt emulsion, aggregates, filler, water, and in some cases, additives. The emulsion is used to bind the aggregates together and to provide a seal to the existing structure as a form of protection, while the aggregates are used to help protect the surface of the structure. In some cases, mineral filler is added to a slurry seal mixture in order to improve its properties. Some commonly used mineral fillers are Portland cement, hydrated lime, limestone dust, or fly ash. Additives may be added to a slurry as well in order to alter the curing time as well (PPRA: Slurry Seal, 2023).

The emulsified asphalt material to be used in the construction of a slurry seal, as specified by PennDOT, is to be a slow-setting emulsion. The other specifications evaluated specified slow-setting or quick-setting emulsions, as detailed in Table 1-5 below.

Table 1-5 Allowable Asphalt Materials in Slurry Seal Applications

Specification	Types of Asphalt Material for Use in a Slurry Seal
PennDOT Specification	SS-1h(E-8A), or CSS-1h(E-8C)
ASTM D3910 Specification	SS-1, CSS-1, SS-1h, CSS-1h, QS-1, CQS-1, QS-1h, or CQS1h
ISSA A105 Specification	SS-1, SS-1h, CSS-1, CSS-1h, or CQS-1h
ISSA A115 Specification	Polymer modified asphalt emulsion
NJDOT Specification	Polymer modified asphalt emulsion

It is notable that the ISSA has a second specification, A115 (ISSA A115 Recommended Performance Guideline for Polymer-Modified Emulsified Asphalt Slurry Seal), in which it details the materials and construction processes for slurry seals using polymer modified asphalt emulsion. Similarly, the New Jersey DOT Slurry Seal specification (NJDOT Standard Specifications for Road and Bridge Construction Spec. 902.10 Slurry Seal, 2019) also calls for the use of polymer modified asphalt emulsion in the construction of a slurry seal.

The aggregate gradation requirements to be used in a slurry seal application were different for each of the slurry seal types; in other words, the gradation was dependent on the thickness of the seal. The PennDOT, ASTM D3910, ISSA A105, ISSA A115, and NJDOT slurry seal specifications all specified identical gradation requirements for each of the three slurry seal types. These gradation requirements are presented in Table 1-6 below.

Table 1-6 Slurry Seal Gradation Requirements for Combined Aggregate; Percentage Passing by Weight

Passing Sieve	Type I	Type II	Type III
3/8-inch	100	100	100
No. 4	100	90-100	70-90

No. 8	90-100	65-90	45-70
No. 16	65-90	45-70	28-50
No. 30	40-60	30-50	19-34
No. 50	25-42	18-30	12-25
No. 100	15-30	10-21	7-18
No. 200	10-20	5-15	5-15

The PennDOT slurry seal specification further specifies that the residual asphalt limitation percentages by weight of aggregate are 10% to 16% for Type I slurry, 7.5% to 13.5% for Type II slurry, and 6.5% to 12% for Type III slurry. These are the identical percentages as specified by the ASTM D3910 specification, ISSA A105 specification, and ISSA A115 specification. With a slight comparison, the NJDOT specification specifies 7.5% to 13.5% of residual asphalt by weight of aggregate for all three types of slurry seals. Further, the mineral filler used in the construction of a slurry seal is specified by the ISSA A105, ISSA A115, and NJDOT slurry seal specification to be within the range of 0% to 3% of the weight of the aggregate.

Water is another material added to a slurry seal mixture. The PennDOT specification states that the water must not contain harmful salts and must also be below 150 parts per million (ppm)of hardness. The specification further states that softener can be used if the hardness of the water is above 150ppm. The ISSA A105 and ISSA A115 specifications do not specify specific hardness requirements for the water used in a slurry seal, but they do specify that the water must not contain contaminants or harmful salts. Similarly, the PPRA recommends that potable water be used in slurry seal mixtures (PPRA: Slurry Seal, 2023).

1.3.1.2 Construction of a Slurry Seal

Proper construction of a slurry seal is also important when it comes to the performance of the seal. Slurry seals are generally constructed utilizing a machine that is capable of mixing the materials and then spreading the slurry seal onto the surface with one device. A schematic of the general machine used to construct a slurry seal is shown in Figure 1-4 below. Equipment similar to the one shown in the schematic is specified to be used in slurry seal applications in the PennDOT specification, along with the other specifications evaluated.

In addition to the equipment used to construct a slurry seal, the weather at the time of construction is also a critical aspect for the curing and, therefore, performance of a slurry seal. The PennDOT specification specifies that slurry seals should be constructed when the air and pavement temperatures are both above 50°F. With slight comparison, the ISSA A105 specification states that under the condition that temperatures are rising, slurry seals can be placed when the air and pavement temperatures are greater than 45°F.

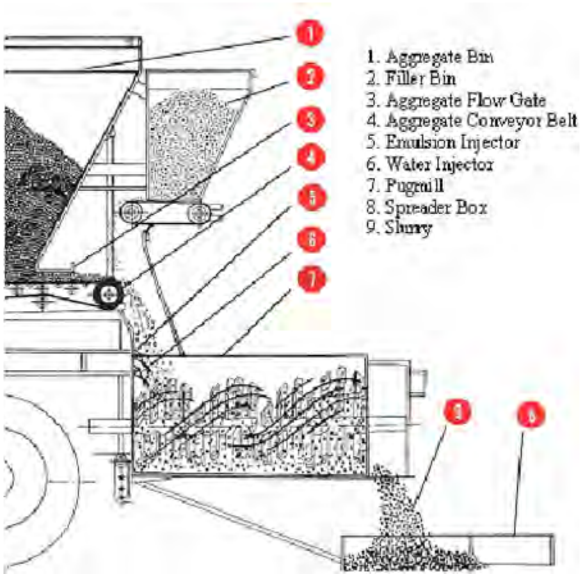

Figure 1-4 Application of Slurry Seal (Oikonomou & Eskioglou, 2007)

Further, in order to condition the surface for the slurry seal application, both the PennDOT and the ISSA specifications state that cracks in the pavement are required to be sealed before the slurry seal application. The PennDOT specification does not specify the width of the crack that warrants sealing, while the ISSA specifications state that cracks wider than ¼-inch should be sealed prior to applying the slurry seal. The ISSA slurry seal specifications also state that tack coats are not required before applying a slurry seal but that they can be used and can be beneficial to the slurry seal performance if the surface of the existing pavement is very dry or is experiencing raveling. Both the PennDOT and ISSA specifications state that the surface should receive a spray application of water prior to applying the slurry seal as well. The application rate of a slurry seal to a pavement surface depends on the type of slurry seal. The application rates between the PennDOT and ISSA specifications varied slightly but followed similar trends and are presented in Table 1-7 below.

Table 1-7 Slurry Seal Application Rates

Slurry Seal Type	PennDOT Spec. Application Rate (lb/yd^2)	ISSA A105 Spec. Application Rate (lb/yd^2)
Type I	6 - 10	8 - 12
Type II	10 - 15	10 - 18

Type III	15 or more	15 - 22

Once the slurry seal has been applied to the surface, the PennDOT specification states that the pavement should not be subjected to traffic prior to it completely curing. The specification does not specify specific requirements on timing.

1.3.2 Polymer-Modified Emulsified Asphalt Paving System (Micro Surfacing)

Micro surfacing is a thin layer of a homogeneous mixture composed of polymer-modified emulsified asphalt, aggregate, filler, water, and other additives applied to the surface of an existing pavement. Its purpose is to resurface or fill minor ruts in the pavement. Micro surfacing is similar to slurry sealing, requiring all of the materials needed in a slurry seal, but micro surfacing generally sets at a faster rate than slurry seals do, allowing them to be more versatile and be implemented in locations where a slurry seal may not be applicable, such as in areas that are heavily shaded (City of Davis, 2024). The PennDOT specification (PennDOT Publication 408/2020 - Section 483 - Polymer-Modified Emulsified Asphalt Paving System (Micro Surfacing), 2020) separates micro surfacing into three types dependent on their purpose. The first two types are used to address surface distresses such as cracks or voids, level the pavement surface, as well as to correct shallow to moderate ruts. The third type of micro surfacing uses more coarse aggregate and, as per the PennDOT specification is used to fill deeper ruts, up to 2 inches. Some of the additional specifications evaluated, such as that of the Indiana DOT (INDOT Standard Specifications Section 411 - Warranted Micro-Surfacing), only specify two types of micro surfacing applications: one to surface or level an existing pavement and the other to fill ruts in an existing pavement. A significant benefit of micro surfacing is its ability to cure within a short period of time, generally permitting traffic to travel over it within one hour of its application (ISSA A143 Recommended Performance Guideline for Micro Surfacing, 2023). In this Section 1.3.2, the PennDOT micro surfacing specification will be compared with the equivalent micro surfacing specifications from INDOT, NJDOT (NJDOT Standard Specifications for Road and Bridge Construction Spec. 902.09 Micro Surfacing, 2019), and ISSA.

1.3.2.1 Materials for Micro Surfacing

As described, micro surfacing is a thin layer, applied to the surface of an existing pavement. Its purpose is to correct distresses existing on the pavement or fill ruts. A micro surfacing layer comprises polymer modified emulsified asphalt, aggregate, filler, water, and possibly other additives.

The allowable materials used in micro surfacing applications differed slightly between the PennDOT and other agency or organization specifications evaluated. All four of the specifications evaluated specified that polymer modified emulsified asphalt should be used in micro surfacing applications, but there were slight differences in the required aggregate gradations to be used in micro surfacing applications, as well as slight differences in allowable fillers to be used. The INDOT specification noted that Portland cement should be used as the filler in micro surfacing applications, while PennDOT specified the use of Portland cement or hydrated lime where allowable. Further, the ISSA specification noted that the filler used in micro surfacing applications could be Portland cement, hydrated lime, limestone dust, fly ash, or other materials with approval.

The overall properties of the micro surfacing mix designs showed significant similarities across all of the specifications evaluated, as shown in Table 1-8 below.

Table 1-8 Micro Surfacing Mix Design Properties

Property	Test Method	INDOT, NJ DOT, ISSA, and PennDOT Specification Mix Design Property Requirements
Wet Cohesion	ISSA TB 139	
	30min	12 kg-cm min
	60min	20kg-cm min
Wet Track Abrasion Loss	ISSA TB 100	
	1 hour soak	50 g/ft^2
	6 day soak	75 g/ft^2
Mix Time	ISSA TB 113	120 seconds min
Classification of Compatibility	ISSA TB 144	11 grade points min
Wet Stripping	ISSA TB 114	Pass (90% min)
Loaded Wheel Test	ISSA TB 147	Vertical 10% max Lateral 5% max

1.3.2.2 Construction of a Micro Surface

Many of the construction aspects of slurry seals specified by each of the entities or organizations are similar to each of their construction specifications for micro-surfacing. Thus, their differences and similarities remain relatively constant when comparing them.

When applying a micro surface to an existing pavement, the PennDOT specification details that it must be placed when the air temperature is at least 50°F and when neither rain nor freezing temperatures are expected within 24 hours of applying the micro surface. These guidelines align with the PPRA Micro Surfacing recommendations (PPRA Micro Surfacing Treatments, 2023). Additionally, before applying the micro-surface to pavement, the Indiana DOT specification and the ISSA specification A143 both state that cracks with a width of ¼-inch or greater should be sealed. Similar to the slurry seal specification, the ISSA A143 specification states that a tack coat is not required before applying a micro-surface, unless an asphalt pavement is very dry, or if the roadway surface is composed of concrete. Similarly, the PennDOT micro-surfacing specification states that tack coats should be placed prior to a micro-surface on concrete pavements.

Before allowing traffic onto the roadway, the PennDOT specification states that the micro-surface should be compacted with a pneumatic tire roller with pressure between 40psi and 60psi. In comparison, the ISSA A143 specification does not specify a need for added compaction of a micro-surface, but that the compaction from traffic loading will provide sufficient compaction for the additional layer to the surface. The ISSA A143 specification does state that in some cases, such as at airports, rolling may be required. After the application of the micro-surface, the PennDOT specification states that traffic should be permitted to travel on the roadway after the micro-surface has "set sufficiently" to the point where the vehicles will not disrupt the newly laid materials. The specification does not note a specific time range to be used for allowing traffic on a new micro-surface.

1.3.3 Ultra-Thin Bonded Wearing Course

An ultra-thin bonded wearing course (UTBWC) consists of a layer of emulsified asphalt material to the surface of an existing pavement, overlaid with a thin hot-mix asphalt course. The initial layer of emulsified asphalt is also known as ultra-thin friction course emulsified asphalt or UTFCEM. UTBWC, also sometimes known as Ultra-Thin HMA Lifts, are implemented to address several distresses that may be present in a pavement, such as raveling, loss of friction, cracking, or others (PPRA: Ultra Thin Lift HMA, 2024). The PennDOT UTBWC specification (PennDOT Publication 408/2020 - Section 489 - Ultra-Thin Bonded Wearing Course, 2020) will be compared with the Indiana DOT UTBWC specification (INDOT Standard Specifications Section 413 - Ultra Thin Bonded Wearing Course, Warranted), and the Michigan DOT Ultra-Thin Lift specification (Michigan DOT Guide Specification for HMA Ultra-Thin, 2005).

1.3.3.1 Materials for an Ultra-Thin Bonded Wearing Course

The first material required in the application of an UTBWC is emulsified asphalt, applied to the surface to form the UTFCEM. The remainder of the materials required are those used in a hot mix asphalt mix, asphalt binder, and fine and coarse aggregates.

1.3.3.2 Construction of an Ultra-Thin Bonded Wearing Course

The construction of an UTBWC is not permitted to occur during the months of November 1st to March 31st if the mixtures use PG 64S-22, or not during the months of October 15th to March 31st if the mixture uses PG 64E-22 in Pennsylvania, as per the PennDOT specification. The specification also states that the surface of the pavement must be dry to apply an UTBWC, and the temperature of the air and of the pavement surface must be above 50^{0}F. The PennDOT specification also states that cracks with a width greater than or equal to ¼-inch that exist on the surface of the pavement should be sealed prior to applying an UTBWC. Once the existing pavement surface has been prepared, the first step in laying an UTBWC is applying the UTFCEM. The PennDOT specification states that this layer of emulsified asphalt should be applied to the surface at 0.15-0.25 gallons per yard squared. Comparatively, the Michigan DOT specification states that this layer should be applied to the surface at a rate of 0.11-0.15 gallons per yard squared. The Indianan DOT specification states that this layer should be applied at a rate of 0.14-0.20 gallons per yard squared. The PennDOT specification then states that within the first five seconds of the application of the emulsified asphalt to the pavement surface, the HMA (UTBWC) should be applied to the surface. The PennDOT specification states that the application rate of the HMA to the surface is dependent on the nominal maximum aggregate size (NMAS) of the coarse aggregate in the mix but ranges from 45 pounds per yard squared to 85 pounds per yard squared. In comparison, the Michigan DOT specification states a target application rate of 83 pounds per yard squared.

After the application of the HMA to the surface, it must be rolled and compacted. The PennDOT specification states that the compaction must commence immediately after the material is placed onto the surface, using a steel double-drum asphalt roller. It also states that the mass of the roller must be at least 8 tons and must perform at least two passes over the newly laid layer. The Michigan and Indiana DOT specifications also specify the rolling, with the Indiana DOT stating that three roller passes are required over the surface, with the ability to put a minimum of 150 pounds per inch to the surface.

SECTION 2: DEVELOPMENT AND ADMINISTRATION OF SURVEY FOR PENNSYLVANIA ENTITIES

A survey on current practices and guidelines for asphalt seal coating and additional pavement preservation treatments was distributed to transportation agencies throughout the state of Pennsylvania. It was distributed to representatives in all 12 of the PennDOT districts, along with county and municipality transportation entity representatives. There were 63 total respondents to the survey. The map in Figure 2-1 below depicts Pennsylvania counties that are represented in the survey responses (a county is marked as completing the survey if at least one representative from the county or from a municipality within that county completed the survey). Four of the 12 PennDOT districts completed the survey: Districts 9, 10, 11, and 12. Survey results from PennDOT, counties, and municipalities are presented together in the same figures and tables throughout the report.

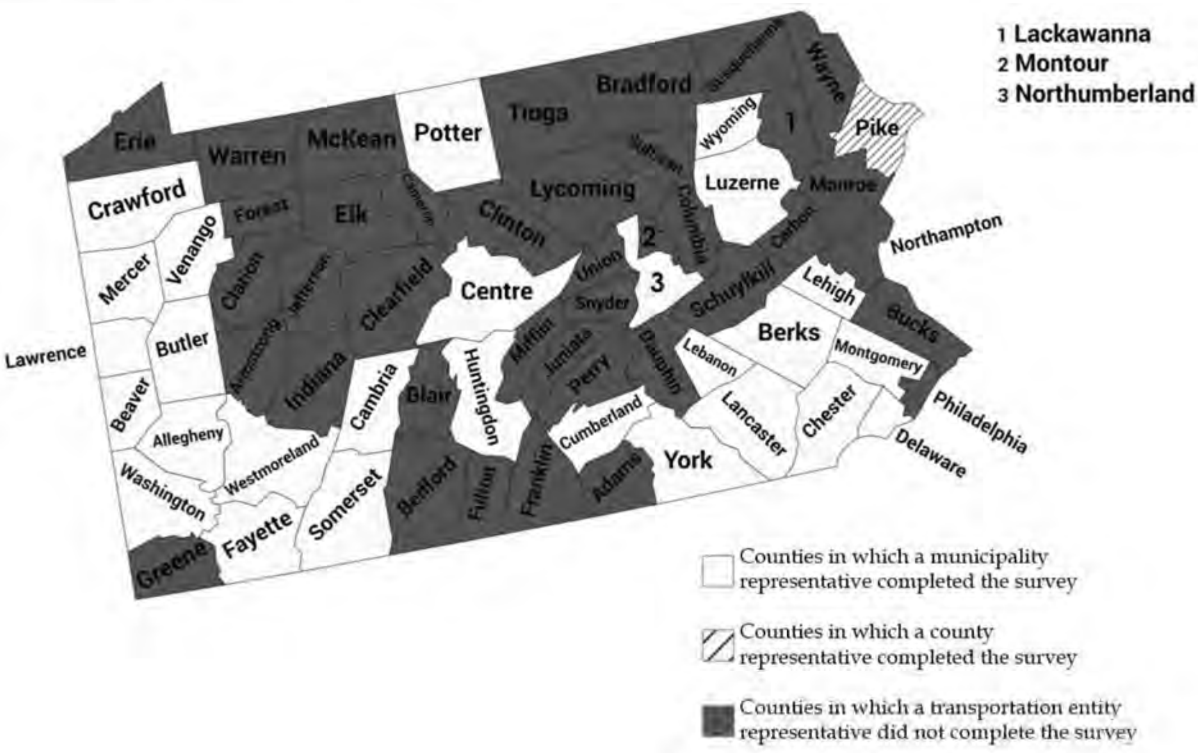

Figure 2-1 Distribution of Survey Respondents and Their Pennsylvania County

The following entities are represented in the survey results:

- PennDOT Districts
    - District 9, District 10, District 11, District 12
- Pennsylvania Counties
    - Pike County

- Pennsylvania Municipalities
    - Big Beaver Borough (Beaver County), Borough of Akron (Lancaster County), Borough of Carlisle (Cumberland County), Borough of Media (Delaware County), Brecknock Township (Lancaster County), Central City Borough (Somerset County), Centre Township (Berks County), Cherry Township (Butler County), Clay Township (Butler County), Clinton Township (Butler County), Concord Township (Delaware County), Cranberry Township (Venango County), Deer Creek Township (Mercer County), East Greenville Borough (Montgomery County), East Pikeland Township (Chester County), East Vincent Township (Chester County), Foster Township (Luzerne County), Harrison Township (Potter County), Hermitage Street Dept. (Mercer County), Lebanon City Public Works (Lebanon County), Ligonier Township (Westmoreland County), Londonderry Township (Bedford County), Lower Macungie Township (Lehigh County), Lower Tyrone Township (Fayette County), Luzerne Township (Fayette County), Mt. Joy Township (Lancaster County), Municipality of Monroeville (Allegheny County), Nicholson Township (Wyoming County), North Centre Township (Columbia County), North Codorus Township (York County), Oakland Township (Butler County), Oakmont Borough (Allegheny County), Pequea Township (Lancaster County), Peters Township (Washington County), Point Township (Northumberland County), Potter Township (Centre County), Salisbury Township (Lancaster County), Scott Township Public Services (Lawrence County), South Fayette Township (Allegheny County), Spring Garden Township (York County), Springfield Township (York County), State College Borough (Center County), Sugar Grove Township (Mercer County), Summerhill Township (Cambria County), Thornbury Township (Chester County), Township of Lower Merion (Montgomery County), Upper Moreland Township (Montgomery County), Upper Salford Township (Montgomery County), Warriors Mark Township (Huntingdon County), West Donegal Township (Lancaster County), West Mead Township (Crawford County), Wilmington Township (Lawrence County)

Appendix A of this report presents the questions from the survey. In the survey, the following definitions were used to clarify the scope of the questions:

- **Asphalt Seal Coat:** represents the application of emulsified asphalt, immediately followed by the application of coarse aggregate. (Also commonly called a "chip seal").
- **Asphalt Fog Seal**: represents a thin application of bituminous material applied to the surface. It may also include an additional application of fine aggregate on top of the bituminous material application.
- **Asphalt Surface Treatment:** represents two applications of emulsified asphalt, with each application immediately followed by an application of coarse aggregate. (Also commonly called a "double chip seal").
- **Slurry Seal:** represents a mixture of slow-setting emulsified asphalt, fine aggregate, and mineral filler with water added to produce slurry consistency mixed in a traveling plant and spread through a squeegee screed.
- **Micro-surfacing:** represents a thin surface paving system composed of polymer-modified emulsion, crushed aggregate, mineral filler, water, and field control additives as needed.
- **Ultra-Thin Bonded Wearing Course (UTBWC):** represents the construction of a polymer-modified emulsified asphalt membrane immediately overlaid with an ultra-thin bonded wearing course of hot-mix asphalt concrete in one pass of a single paving machine.
- **Pavement Preservation Treatments:** represents all of the above-mentioned preservation methods.

2.1 STATE-OF-THE-PRACTICE RELATED TO THE USE OF PAVEMENT PRESERVATION TREATMENTS

Of the 63 responding transportation entities, 75% (47/63) reported that they implement pavement preservation treatments on their roadways, while the remaining 25% (16/63) reported that they do not conduct any pavement preservation treatments, as displayed in Figure 2-2.

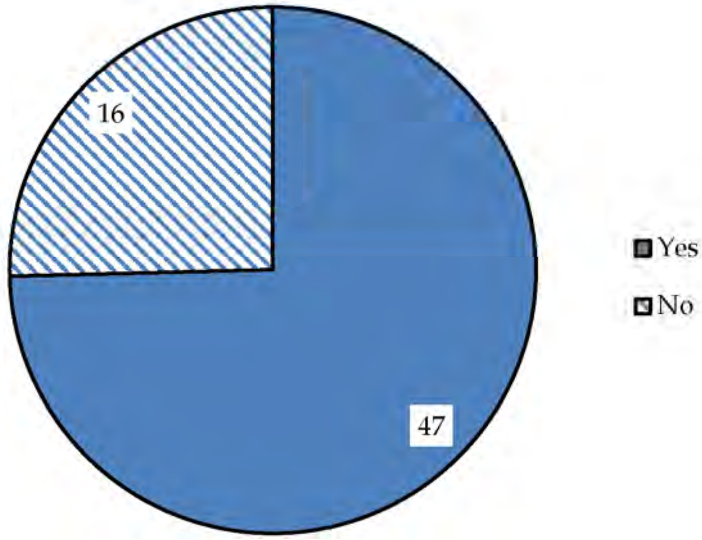

Figure 2-2 Distribution of Responding Agencies with Respect to if They Implement Pavement Preservation Treatments on their Roadways (number of responses = 63)

Of the 47 agencies that reported treating their roadways with preservation treatments, the most commonly implemented pavement preservation treatment was the asphalt seal coat, followed by the asphalt surface treatment (Figure 2-3). The asphalt fog seal, micro surfacing, and UTBWC have also been implemented by many of the responding agencies. Additional pavement preservation treatments utilized by the responding agencies are reported in Table 2-1.

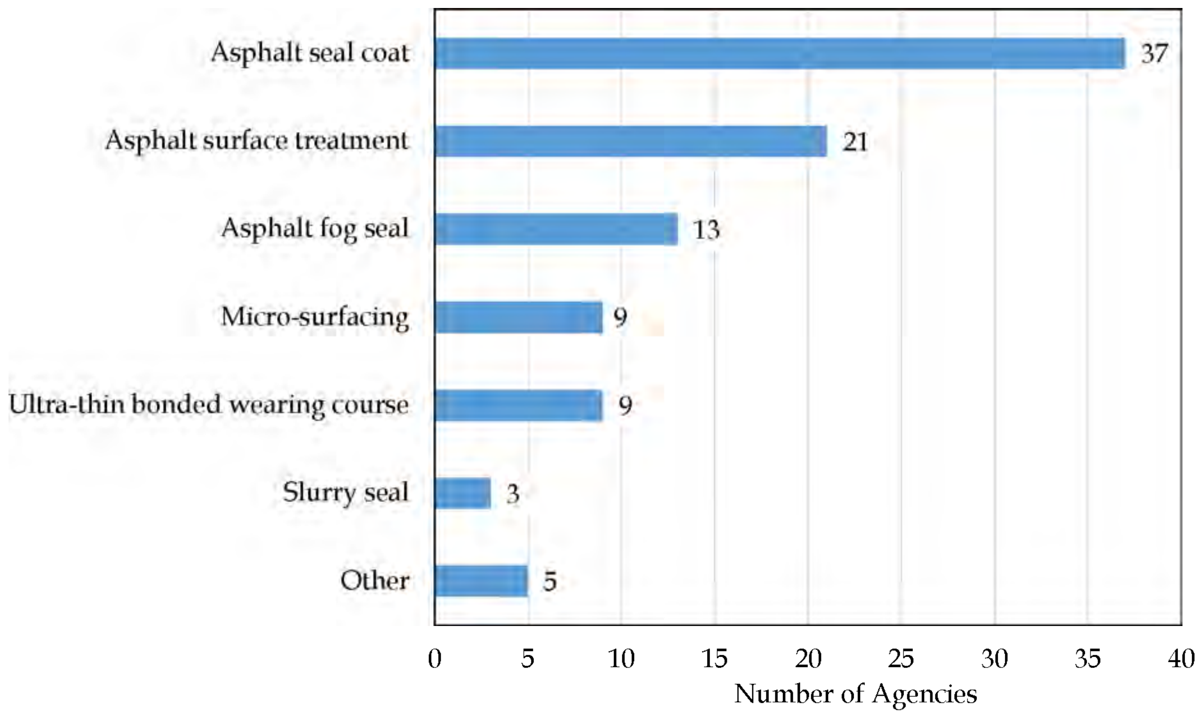

Figure 2-3 Distribution of Responding Agencies and Their Use of Pavement Preservation Treatments Over the Past 5 Years (number of responses = 47)

Table 2-1 Agency Reported "Other" for Pavement Preservation Treatments Implemented by Their Agency

Pike County does not have a road maintenance department but owns several local roads. When work is required on these roadways Pike County always contracts out the needed repairs based on the information our engineer provides.
MC70 and seal millings
Leveling coat
Asphalt rejuvenator
Triple seal

Of the above-mentioned preservation treatments, it was reported by 78% (36/46) of the agencies that these treatments are generally performed by contractors only, as shown in Figure 2-4. 20% of the agencies reported that some of the treatments are applied by contractors and some by agency crews, and only 2% (1/46) of responding agencies reported that these treatments are only performed by their agency crews.

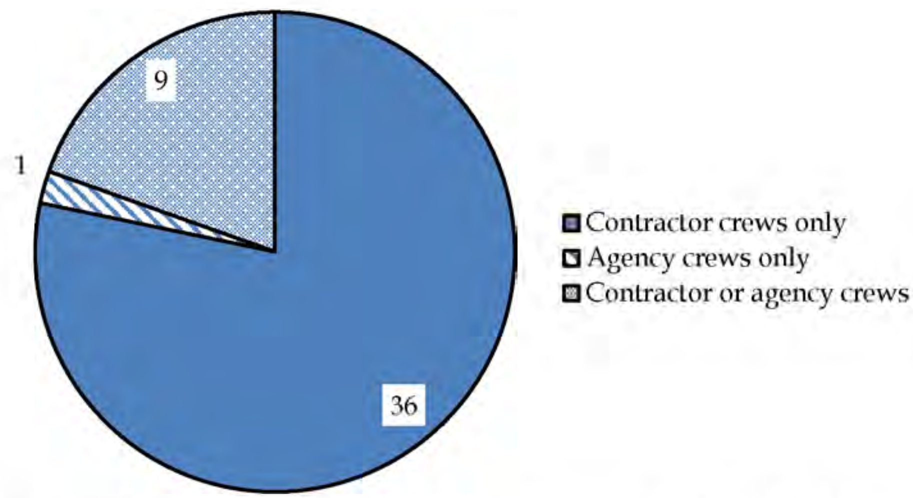

Figure 2-4 Distribution of Responding Agencies and Who Generally Performs Their Preservation Treatments (number of responses = 46)

The importance of factors considered when determining which pavement preservation treatment to implement was spread across a range of factors, as shown in Figure 2-5**Error! Reference source not found.**. The existing primary distresses on the roadway was most commonly ranked as the number one factor considered, while the specific type of roadway (or functional class of the roadway) was ranked as the number two factor considered. The ride quality of the existing pavement had most agencies rank it as the third factor considered, while the existing pavement structure and the cost of preservation options were ranked as the fourth and fifth most important factors considered. Additional factors considered by the responding agencies are shown in Table 2-2.

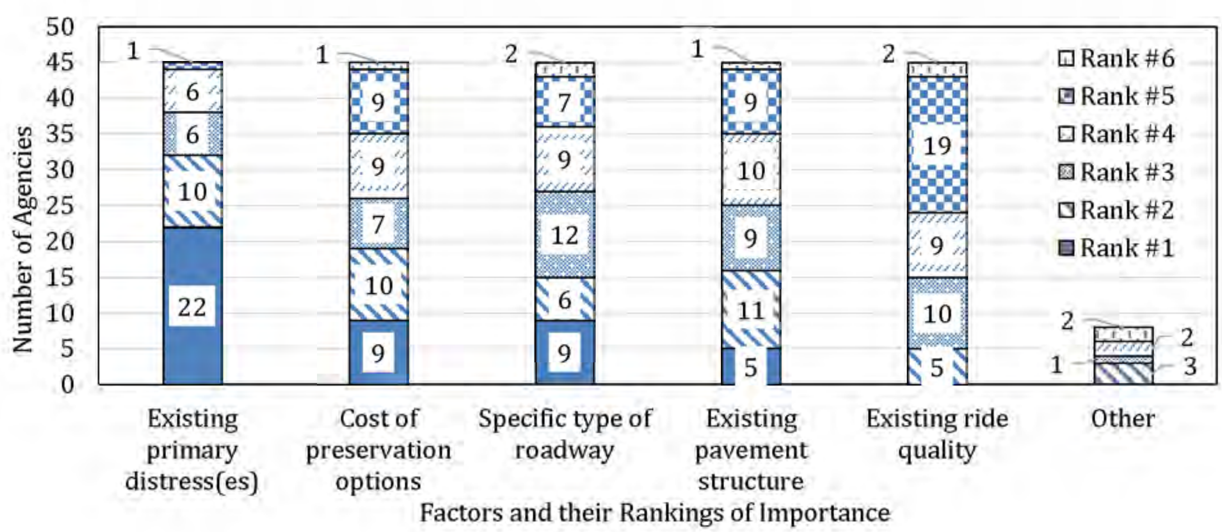

Figure 2-5 Distribution of Responding Agencies and their Rankings of Importance of Factors Considered when Selecting which Preservation Treatment Type to Implement on a Project (number of responses = 45)

Table 2-2 Agency Reported "Other" for Factors Considered when Selecting which Preservation Treatment Type to Implement on a Project

Rank	"Other"
2	Road surface age
2	Safety
2	Roadway management software ranking
3	Time since the last treatment
4	Usage (traffic)
4	Funding sources
6	Existing land use adjacent to the roadway
6	Final aesthetic/Appearance

When implementing these pavement preservation options, 52% (24/46) of responding agencies reported that they always perform a pre-design investigation before carrying out the treatment (**Error! Reference source not found.**). An additional 26% (12/46) reported that they sometimes carry out pre-design investigations, while 20% (9/46) of the agencies reported that they do not conduct pre-design investigations.

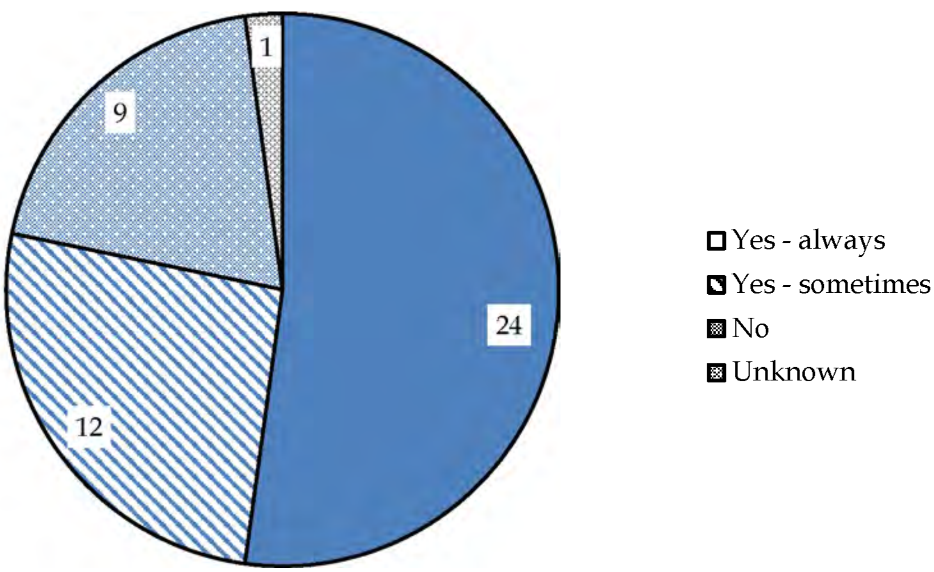

Figure 2-6 **Distribution of Responding Agencies that Perform a Pre-Design Investigation before Carrying-Out Pavement Preservation Treatments (number of responses = 46)**

2.2 STATE-OF-THE-PRACTICE RELATED TO ASPHALT SEAL COAT TREATMENTS

Of the 36 agencies that reported implementing asphalt seal coating treatments on their pavements, 47% (17/36) reported that over the last five years, they have carried out less than five seal coating applications per year, as shown in Figure 2-7. 31% (11/36) of the responding agencies reported implementing 5 to 10 applications per year, 6% (2/36) carry out 10 to 20 applications, and 16% (6/36) conduct more than 20 seal coating applications per year.

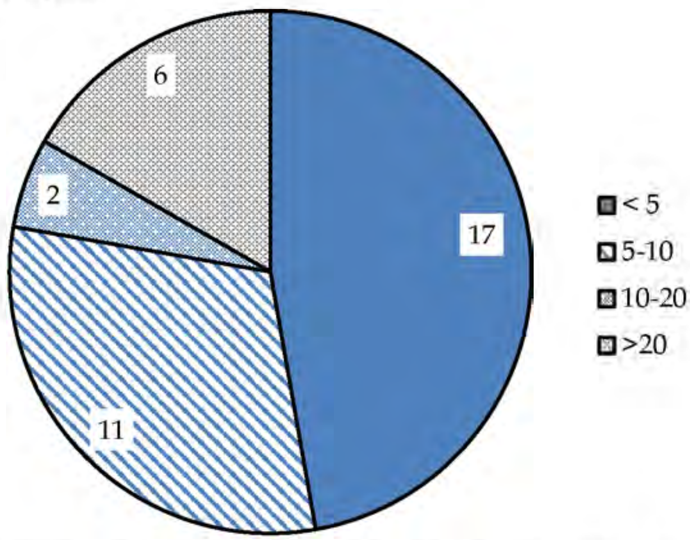

Figure 2-7 Distribution of Responding Agencies with Respect to the Number of Seal Coating Applications they have Carried Out Per Year (over the last 5 Years) (number of responses = 36)

As shown in Figure 2-8, the primary distresses that the responding agencies aim to delay or prevent by implementing asphalt seal coats is fatigue (alligator) cracking, followed by longitudinal cracking, transverse cracking, and block cracking. Other distresses that the responding agencies reported preventing using asphalt seal coatings were loss of skid resistance, raveling, bleeding, rutting, and others, as described in Table 2-3.

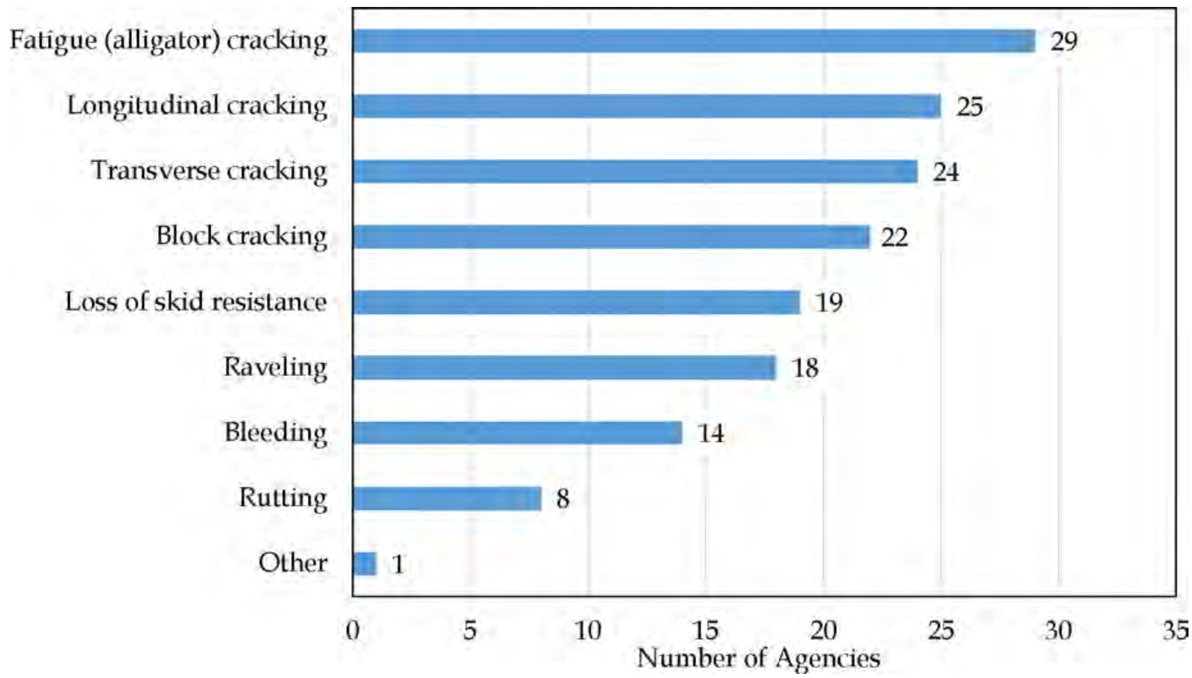

Figure 2-8 Distribution of Responding Agencies and the Distress(es) They Aim to Delay or Prevent by Implementing Asphalt Seal Coats

Table 2-3 Agency Reported "Other" Regarding the Distress(es) They Aim to Delay or Prevent by Implementing Asphalt Seal Coats

Crack seal

Figure 2-9 displays the roadway types (or functional classes) of the pavements that the responding agencies treat with asphalt seal coats. Per the survey results, asphalt seal coats are more commonly carried out on rural local roads, minor collectors, and rural major collectors. They are reportedly less frequently carried out on higher traffic and urban roads.

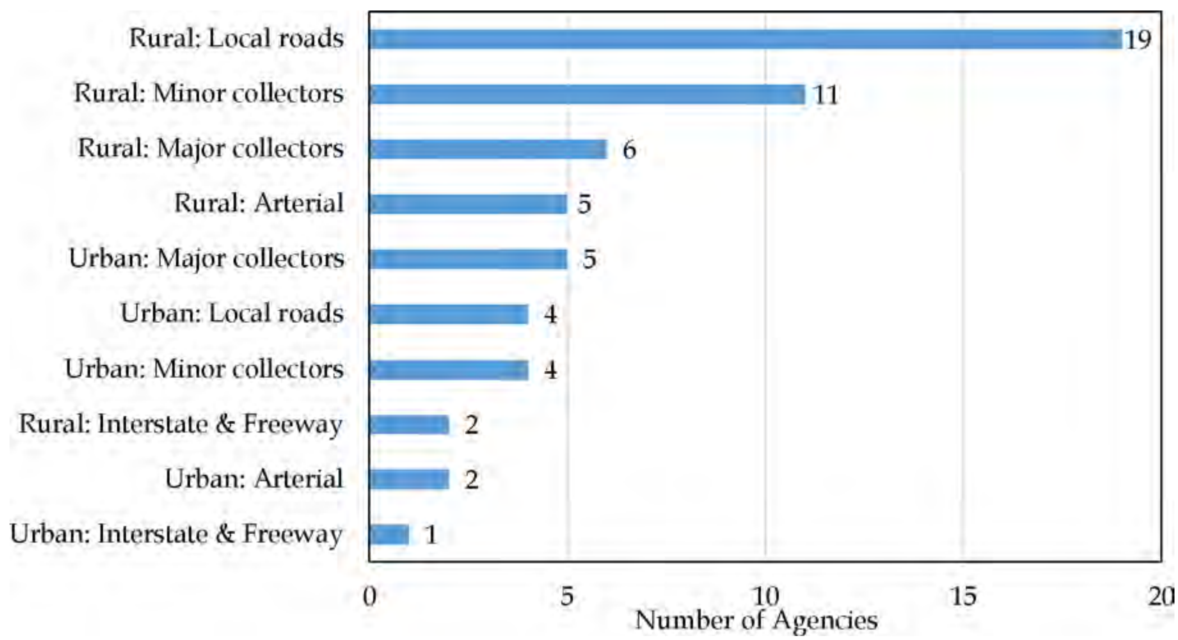

Figure 2-9 Distribution of Responding Agencies and the Roadway Types that They Treat with Seal Coats

2.2.1 Asphalt Seal Coat Materials

As displayed in Figure 2-10, 39% (14/36) of the responding agencies reported that the mix design and the asphalt and aggregate application rates for a seal coating application are determined by the contractors, while 25% (9/36) reported that they keep the application rates and mix design constant for all seal coating applications, and 22% (8/36) of responding agencies reported that their agency determines the application rates and mix designs for seal coating applications based on their agency-specific mix design method. Additional methods for determining application rates and mix designs were reported by responding agencies, as shown in Table 2-4. None of the survey respondents reported that they use the McLeod or Kearby method to determine their seal coating application rates or mix design.

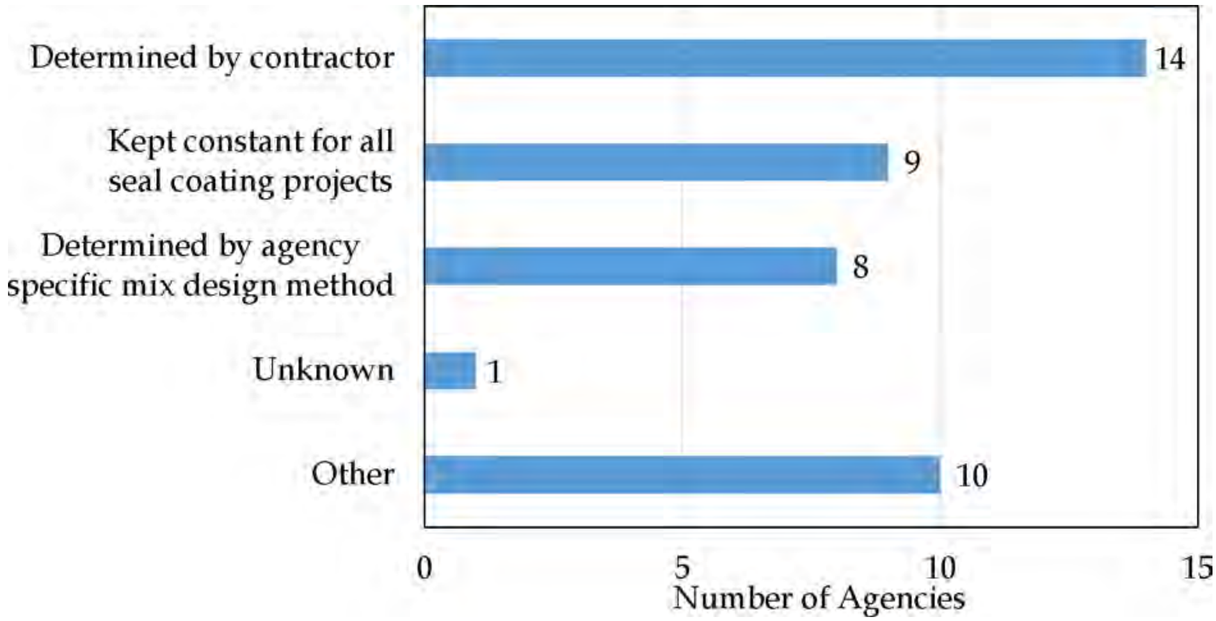

Figure 2-10 Distribution of Responding Agencies with Respect to How They Determine Asphalt and Aggregate Application Rates/Mix Design for Seal Coat Applications (number of responses = 36)

Table 2-4 Agency Reported "Other" with Respect to How They Determine Asphalt and Aggregate Application Rates/Mix Design for Seal Coat Applications

PennDOT Pub 27 Appendix E
Recommendations from PennDOT Local Municipality Service Representative.
Engineer
State contract specs established by joint townships
PennDOT recommendations by Municipal Rep
Our Engineer is involved in bids and design.
PennDOT rulebook
Township engineer
PennDOT spec
Agility with Penn DOT

Per the PennDOT seal coating specification, many types of emulsified asphalt material are allowable. The responding agencies reported that from that list, they select which of the allowable types to use based on a range of factors, as shown in Figure 2-11. The choice of emulsified asphalt material is most commonly based on past performance. Many agencies also reported that contractors determine the type. In addition, agencies reported that they determine the type based on historic use, project needs, cost, and availability of material. Additional methods noted by the responding agencies are shown in Table 2-5.

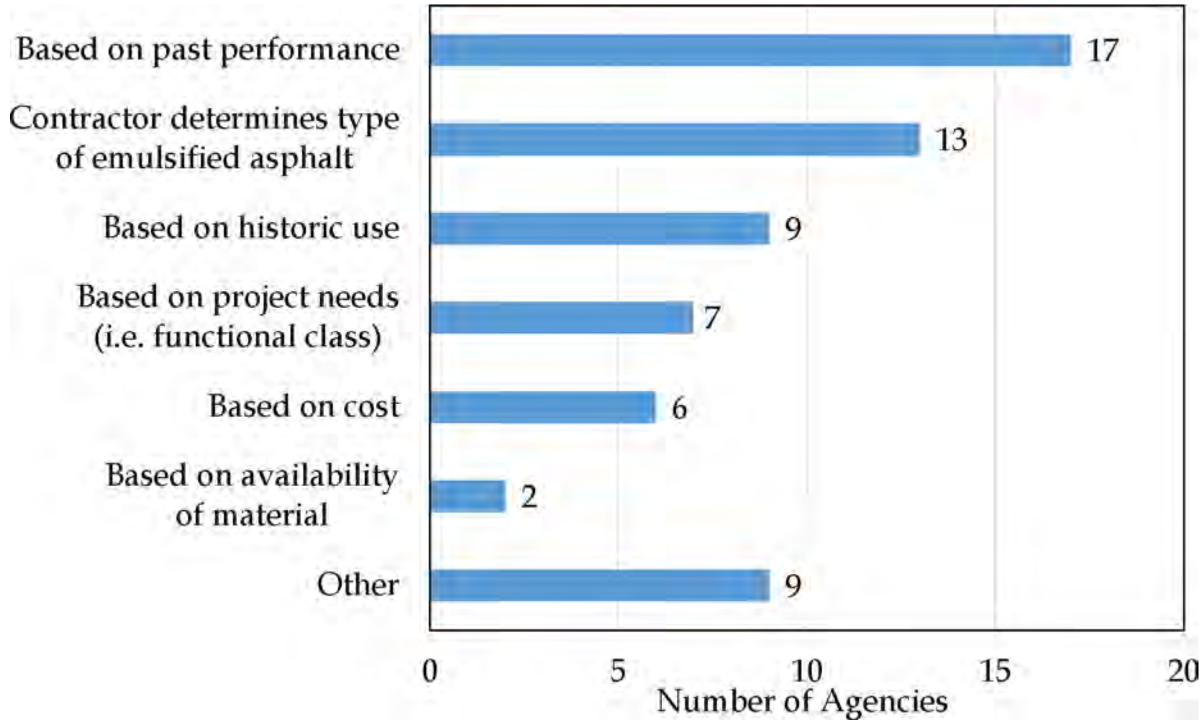

Figure 2-11 Distribution of Responding Agencies with Respect to How They Determine Which Type of Emulsified Asphalt Material to Use in Seal Coating Applications (number of responses = 36)

Table 2-5 Agency Reported "Other" for How They Determine Which Type of Emulsified Asphalt Material to Use in Seal Coating Applications

We always use CRS-2PM
Recommendations from PennDOT Local Municipality Service Representative
PennDOT Municipal Rep
Engineer
PennDOT rulebook
Township Engineer
Based on PennDOT recommendations
Municipal services specialist
Agility with PennDOT

The PennDOT specification also noted that washed aggregate, precoated aggregate, or recycled asphalt pavement can be used as aggregate material in seal coating applications. The majority of agencies reported that they use only washed aggregate in their applications, as shown in Figure 2-12, while only 4 of 36 agencies reported that they use RAP, and only 3 of 36 agencies reported that they use precoated aggregate in seal coating applications. Of the three agencies that reported that they use precoated aggregate in seal coating applications, two of them reported that they decide when to use precoated aggregate based on the properties of the aggregate that is being used. The other agency reported that they determine when to use it not only based on the properties of the aggregate being used but also based on the existing distresses present in the pavement, as shown in Figure 2-13. None of the responding agencies reported that their decision of when to use precoated aggregate is based on the functional class of the roadway that is receiving the treatment.

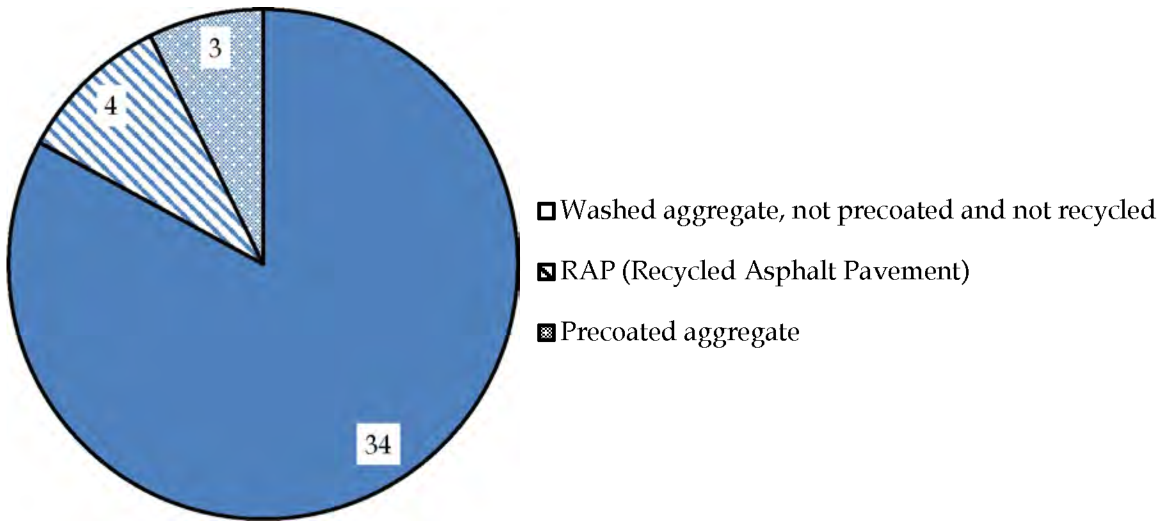

Figure 2-12 Distribution of Responding Agencies with Respect to the Type of Aggregate Their Agency Uses in Seal Coating Applications (number of responses = 36)

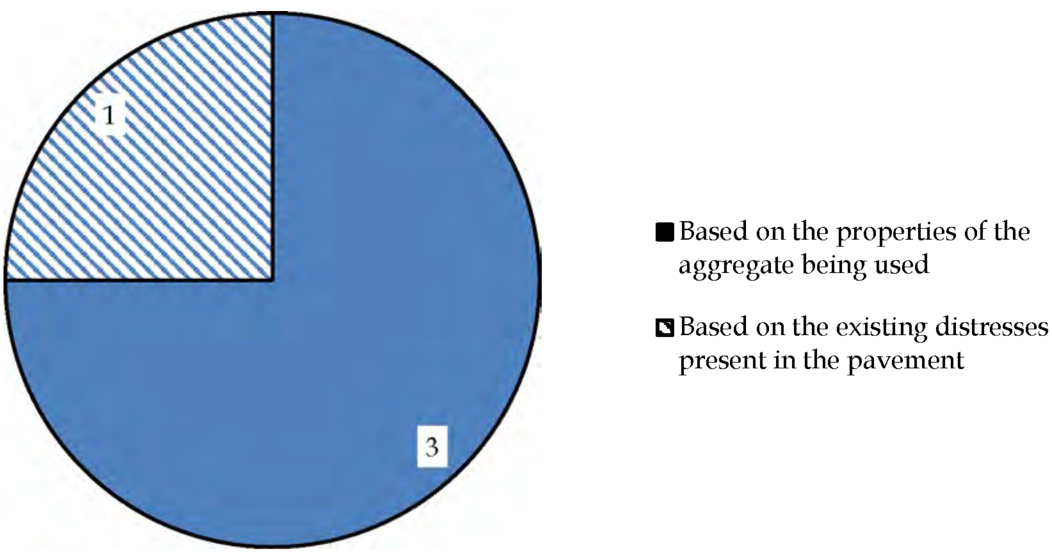

Figure 2-13 Distribution of Responding Agencies with Respect to the Factors that Influence Their Agency's Decision to Use Precoated Aggregate in Place of Not Precoated Aggregate (number of responses = 3)

2.2.2 Asphalt Seal Coat Construction

In addition to the materials used during these preservation treatments, the construction process and application timings are also important. As shown in Figure 2-14, 25% (9/36) of agencies reported that they have determined a timing process that they keep constant for all of their applications, while 22% (8/36) reported that their agency determines it on a project-by-project basis. Despite that, the majority of responding agencies (53%, 19/36) reported that the timings for the application of an asphalt seal coat are determined by the contractors.

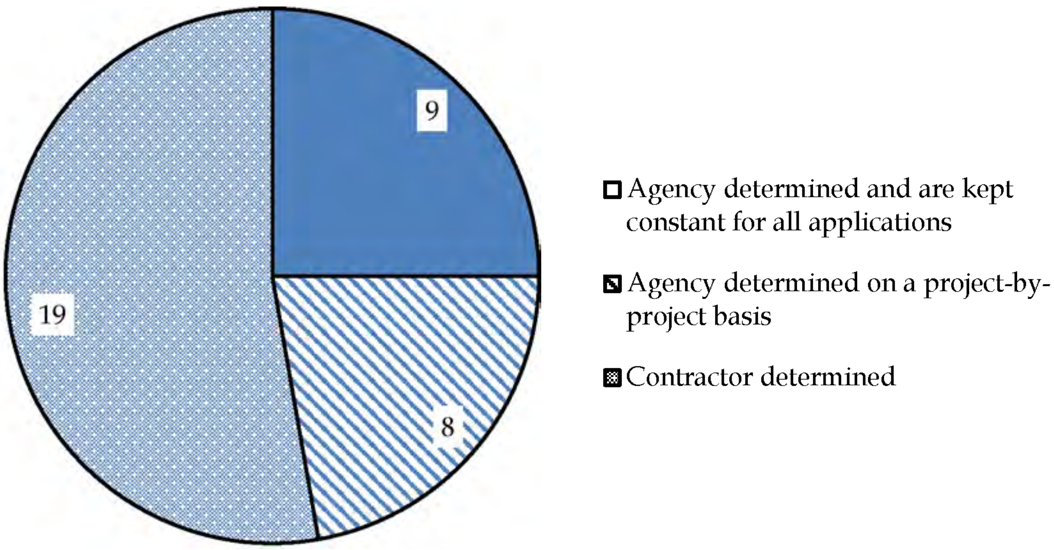

Figure 2-14 Distribution of Responding Agencies with Respect to How Seal Coating Application Timings are Determined (number of responses = 36)

After a seal coating application is performed on a roadway, agencies must also determine when they allow traffic to drive on the treatment pavement. Figure 2-15 shows that 78% (28/36) of the agencies reported that they immediately permit traffic to drive on the pavement after a seal coating application. 8% (3/36) of responding agencies noted that they immediately allow traffic to resume on the pavement but only following a pilot car at the speeds specified in Table 2-6. Another 8% (3/36) of the responding agencies reported that they allow traffic back on the roadway after a certain amount of time. Additional specifics regarding allowing traffic on a roadway following a seal coat are shown in Table 2-7.

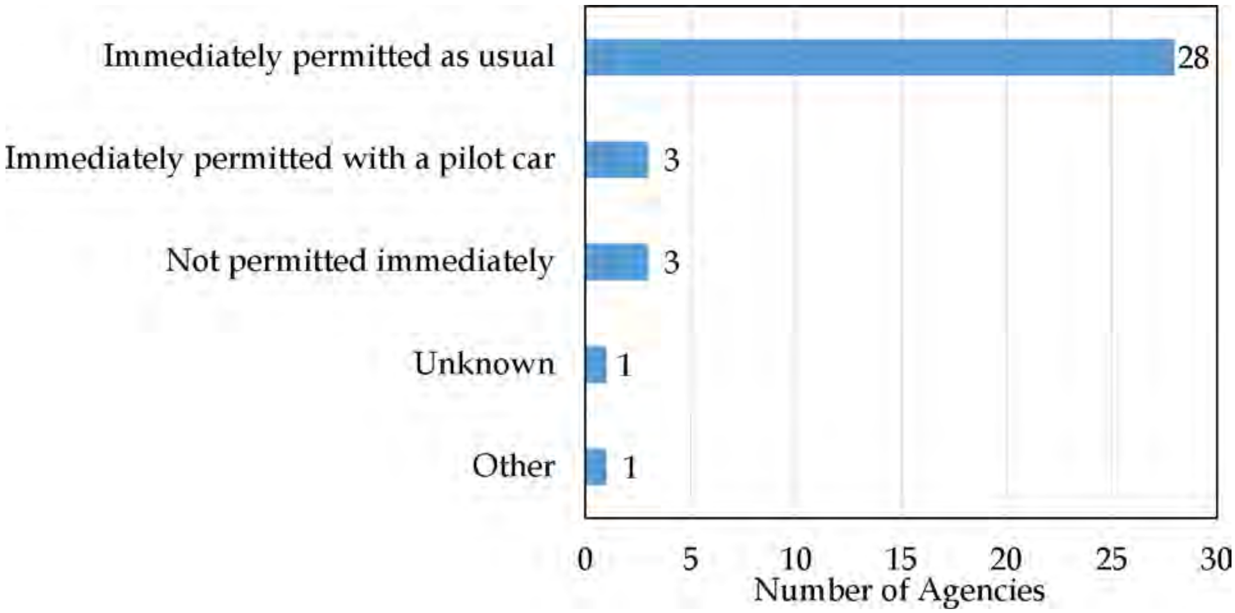

Figure 2-15 Distribution of Responding Agencies with Respect to When Traffic is Permitted to Drive on the Pavement After a Seal Coat Application (number of responses = 36)

Table 2-6 Agency Reported "Speed" That Their Pilot Car Travels at After a Seal Coat Application

10 mph
No specified speed. The pilot car safely navigates traffic.
Posted speed limit

Table 2-7 Agency Reported "Other" for When Traffic is Permitted on the Pavement After a Seal Coat Application

Usually allowed after an hour of cure time for the fog seal.

Of the 8 agencies that reported that they do not immediately allow traffic on the roadway, 12% (1/8) reported that they allow traffic to resume as usual at normal speeds on the treated surface after less than 2 hours, as shown in Figure 2-16. 50% (4/8) reported that they allow the usual traffic on the treated pavement after two to four hours, and 12% (1/8) reported that they do not allow usual traffic on the treated surface until more than six hours after the treatment has been applied. Additional time frames reported by the agencies are shown in Table 2-8.

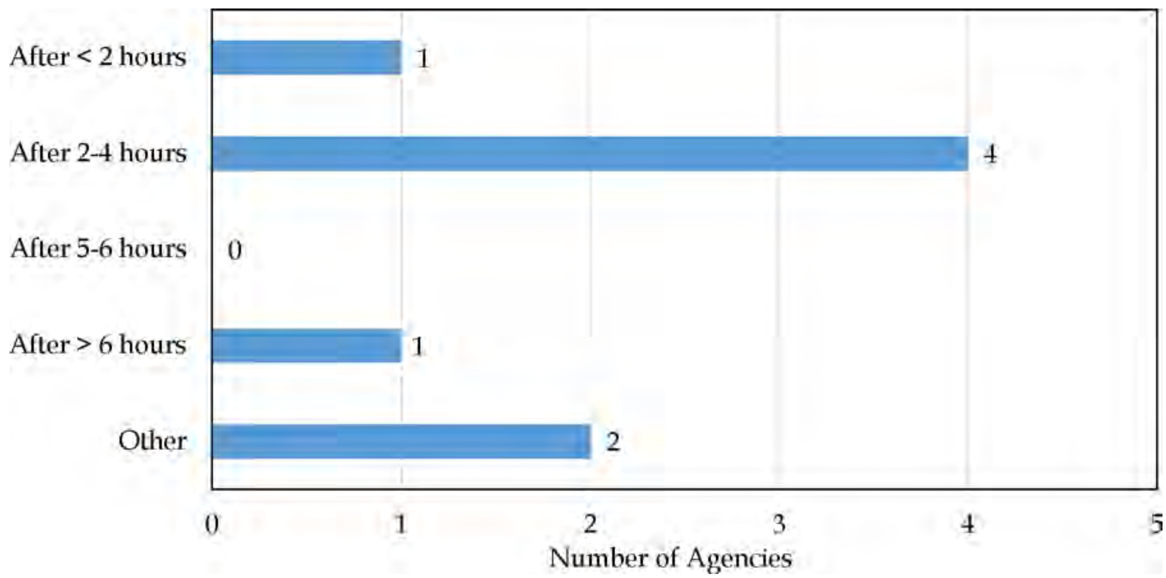

Figure 2-16 Distribution of Responding Agencies with Respect to When Traffic is Able to Resume as Usual, at Normal, on the Treated Surface (number of responses = 8)

Table 2-8 Agency Reported "Other" Regarding How Long After a Seal Coating Application Traffic is Able to Resume at Normal on the Treated Surface

Surface must be checked to ensure that the emulsion asphalt has set up to allow adequate stability and adhesion to prevent flushing and loss of aggregate prevent

After the application of the seal coat, only 11% (4/36) of responding agencies reported that they perform post-construction testing to determine the percent embedment of the aggregate in the asphalt, as shown in **Error! Reference source not found.**. To perform this evaluation, they reported using the methods described in Table 2-9. 75% (27/36) reported that they do not evaluate the percent embedment after the construction of a seal coat, while the remaining 14% (5/36) reported that they were unknown if their agency evaluates percent embedment.

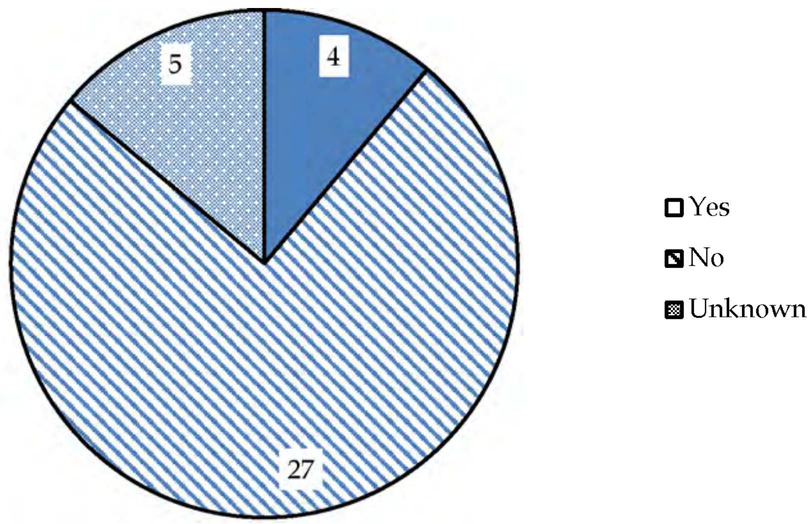

Figure 2-17 Distribution of Responding Agencies with Respect to if They Perform Post-Construction Testing to Determine the Percent Embedment of the Aggregate in the Asphalt (number of responses = 36)

Table 2-9 Agency Reported Method Used to Determine Post-Construction Percent Embedment of the Aggregate in the Asphalt

Visual
Randon manual probing
Roadmaster observation
Visual. Pull out Stone and check embedment.

Of the agencies that apply seal coating treatments to their pavements, 11% (4/35) reported that they always apply fog seals on top of seal coats, while an additional 23% (8/35) reported that they sometimes apply fog seals on top of seal coats as shown in Figure 2-18. The remaining 66% (23/35) reported that their agency never applies fog seals on top of seal coats. Of the 34% (12/35) agencies that reported that they always or sometimes do, they reported applying the fog seals on top of the seal coats after various amounts of time after a seal coating application, with the most common amount of time being within the first week after the seal coating application is applied, as shown in Figure 2-19.

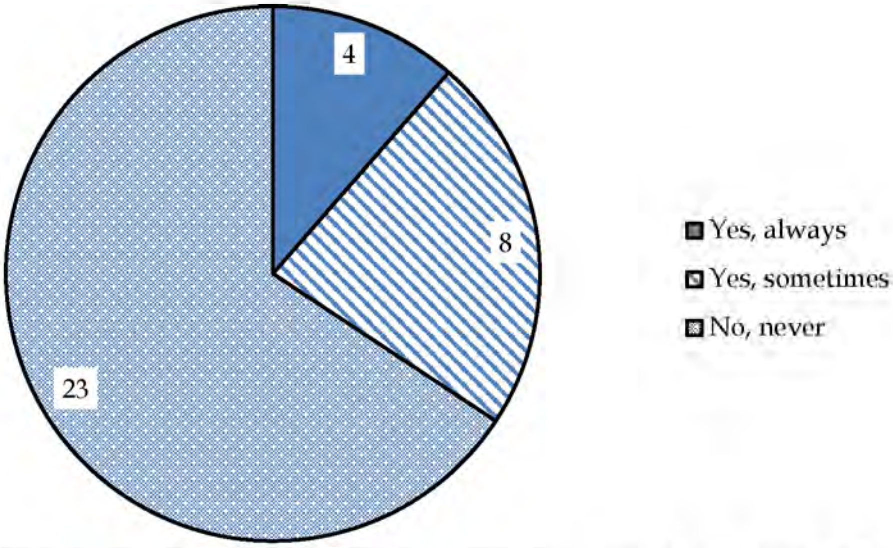

Figure 2-18 Distribution of Responding Agencies with Respect to if They Apply Fog Seals on Top of Seal Coats (number of responses = 35)

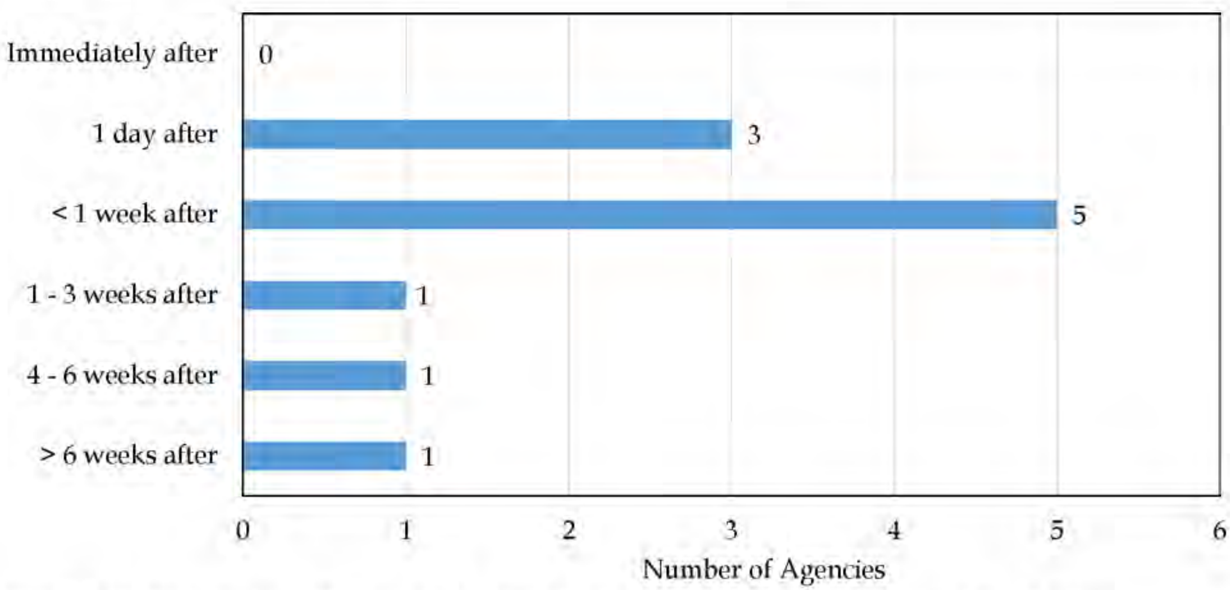

Figure 2-19 Distribution of Responding Agencies Regarding How Long After a Seal Coating Application, a Fog Seal is Applied (number of responses = 11)

2.2.3 Asphalt Seal Coat Expected Life and Challenges

Figure 2-20 shows that the majority (61%, 22/36) of responding agencies reported that they expect their seal coating treatments to have a life expectancy of four to six years, while 17% (6/36) of agencies reported that they expect their seal coats to have a life expectancy of three or fewer years, and another 17% (6/36) reported 7 to 9 years. 3% (1/36) reported that their agency expects their seal coats to last at least 10 years.

Additional time frames of life expectancies reported by responding agencies are shown in Table 2-10.

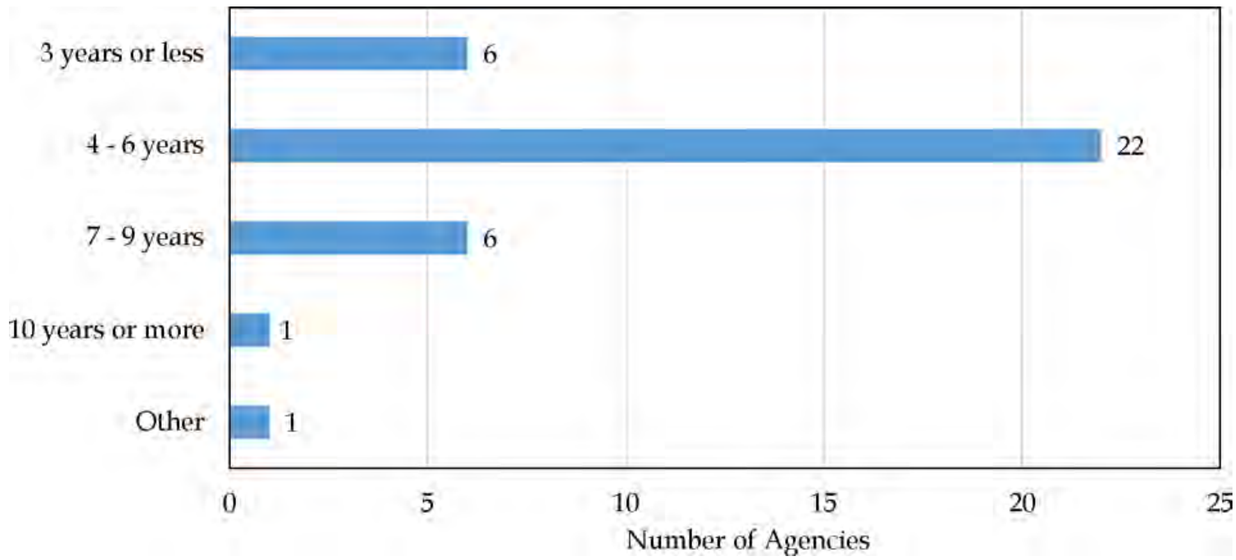

Figure 2-20 Distribution of Responding Agencies with Respect to How Long Their Agency Expects a Seal Coating Treatment Life Expectancy to be (number of responses = 36)

Table 2-10 Agency Reported "Other" with Respect to How Long Their Agency Expects a Seal Coating Treatment Life Expectancy to be

4-7 years

As reported by responding agencies, the most common cause of failures in asphalt seal coats is due to distresses in the existing pavement (31%, 11/36), as shown in Figure 2-21. 17% (6/36) of agencies reported that their seal coats most generally fail due to factors that are not preventable by the mix design or construction processes but rather due to factors such as weather or increased traffic. 6% (2/36) reported that their failures are most commonly due to poor application timing, while another 6% (2/36) reported that theirs are generally due to traffic being permitted to travel on the pavement before proper curing of the treatment has occurred. Only 3% (1/36) of responding agencies reported that their failures are generally due to poor construction quality, while none of the responding agencies noted that the cause of their failing seal coats was due to poor material selection. 22% (8/36) of responding agencies reported that their seal coating applications generally do not fail before the end of their expected life. Additional seal coating failure causes reported by responding agencies are shown in Table 2-11.

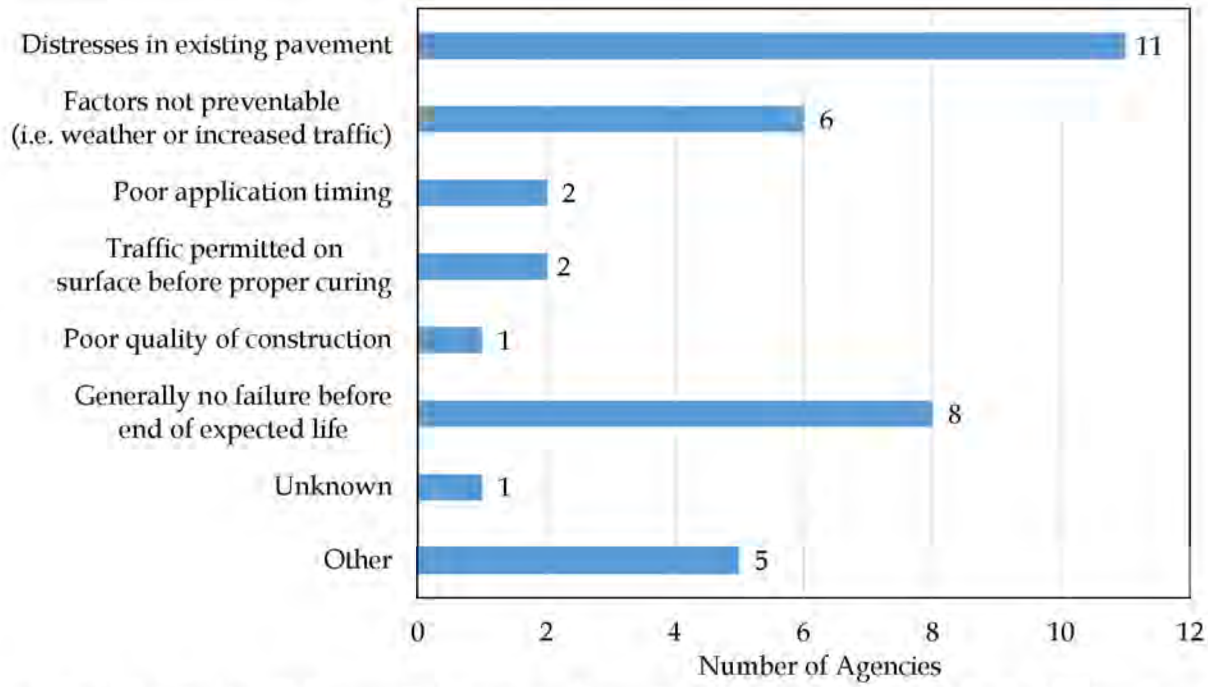

Figure 2-21 Distribution of Responding Agencies Regarding the Most Common Cause of Failures in Asphalt Seal Coat Applications Implemented by Their Agency (number of responses = 36)

Table 2-11 Agency Reported "Other" Regarding Most Common Cause of Failures in Asphalt Seal Coat Applications Implemented by Their Agency

Weather, poor base, farm equipment
Just started
Weather – heavy rains
None
The structure of the asphalt that the seal coat is placed on

2.3 STATE-OF-THE-PRACTICE RELATED TO ASPHALT FOG SEALS

Of the agencies that reported treating their pavements with asphalt fog seals, 92% (11/12) reported that over the last five years, they have carried out less than 5 asphalt fog sealing applications per year, as shown in Figure 2-22. 8% (1/12) of the responding agencies reported carrying out 5 to 10 applications per year.

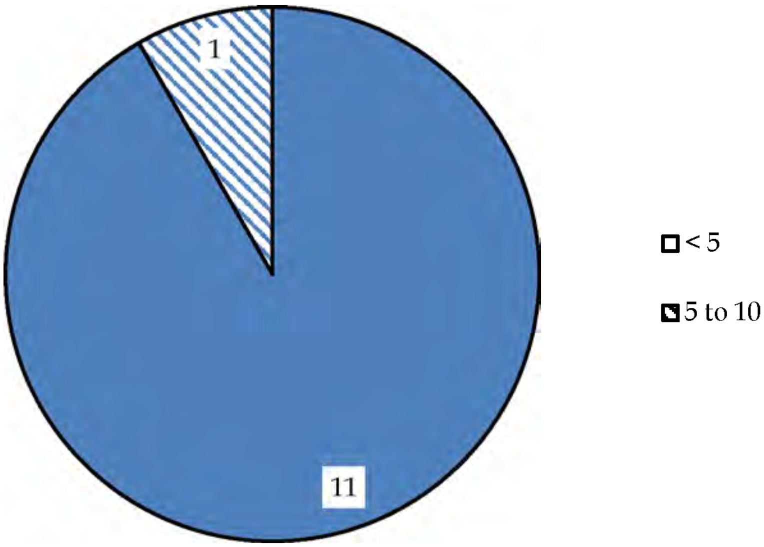

Figure 2-22 Distribution of Responding Agencies Regarding How Many Asphalt Fog Seal Applications They Carry Out Per Year (over the last 5 years) (number of responses = 12)

Of agencies that perform fog seals, 58% (7/12) reported that they only perform fog seals on top of seal coats, 25% (3/12) reported that they only perform fog seals as independent treatments, and 17% (2/12) reported that they apply fogs seals both as independent treatments and on top of seal coats (Figure 2-23).

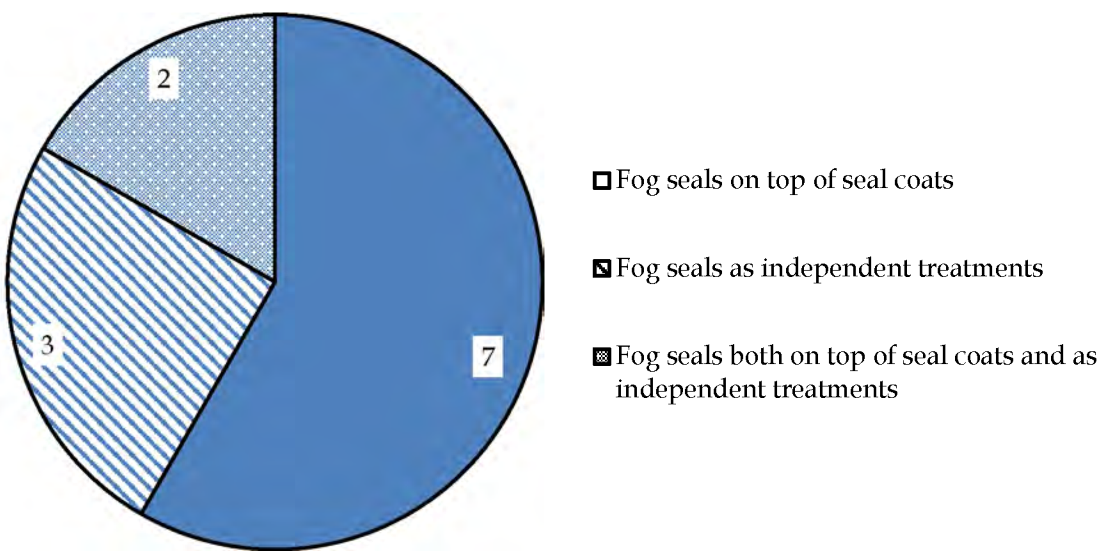

Figure 2-23 Distribution of Responding Agencies with Respect to if They Apply Asphalt Fog Seals as Independent Treatments or in Combination with Asphalt Seal Coats (number of responses = 12)

As shown in Figure 2-24, the primary distresses that the responding agencies aim to delay or prevent by treating with fog seals are fatigue (alligator) cracking, followed by longitudinal cracking, followed by transverse cracking, and block cracking. Agencies also reported that they use asphalt fog seal to delay or prevent reveling and a loss of skid resistance, or others, as shown in Table 2-12.

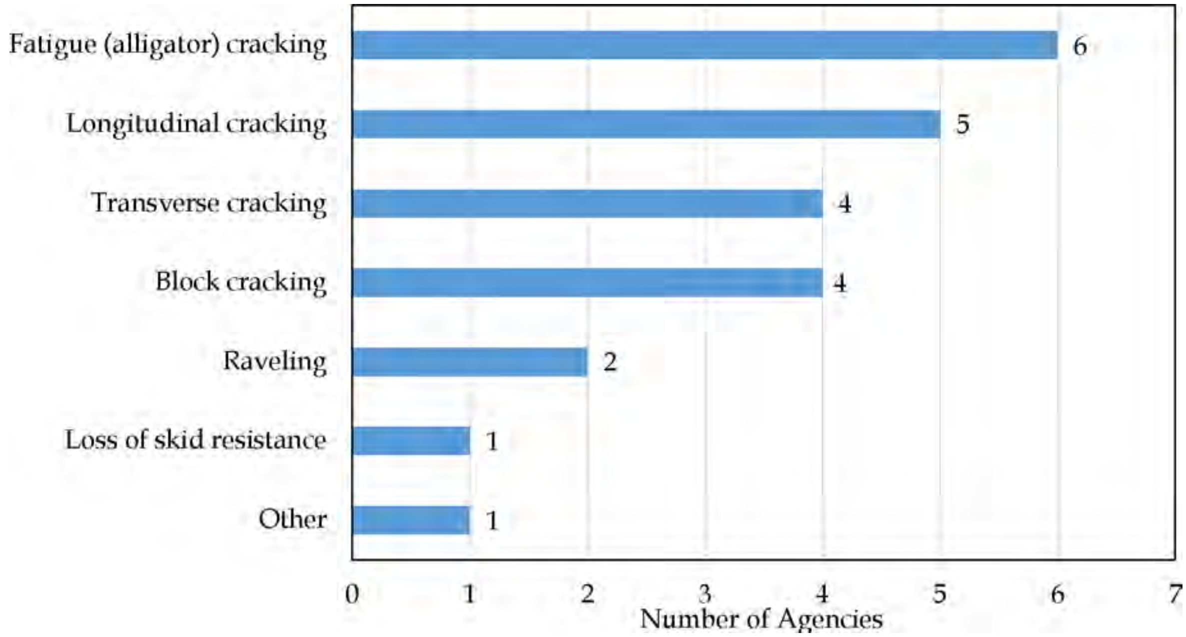

Figure 2-24 Distribution of Responding Agencies and the Distress(es) They Aim to Delay or Prevent by Implementing Asphalt Fog Seals

Table 2-12 Agency Reported "Other" Regarding the Distress(es) They Aim to Delay or Prevent by Implementing Asphalt Fog Seals

Crack seal

Figure 2-25 displays the roadway types (or functional classes) of the pavements that the responding agencies treat with asphalt fog seals. Per the survey results, asphalt fog seals are most commonly used to treat rural local roads. Agencies also reported implementing asphalt fog seals on urban local roads, rural minor collectors, and urban minor collectors, along with rural arterials, urban major collectors, rural major collectors, and urban arterials.

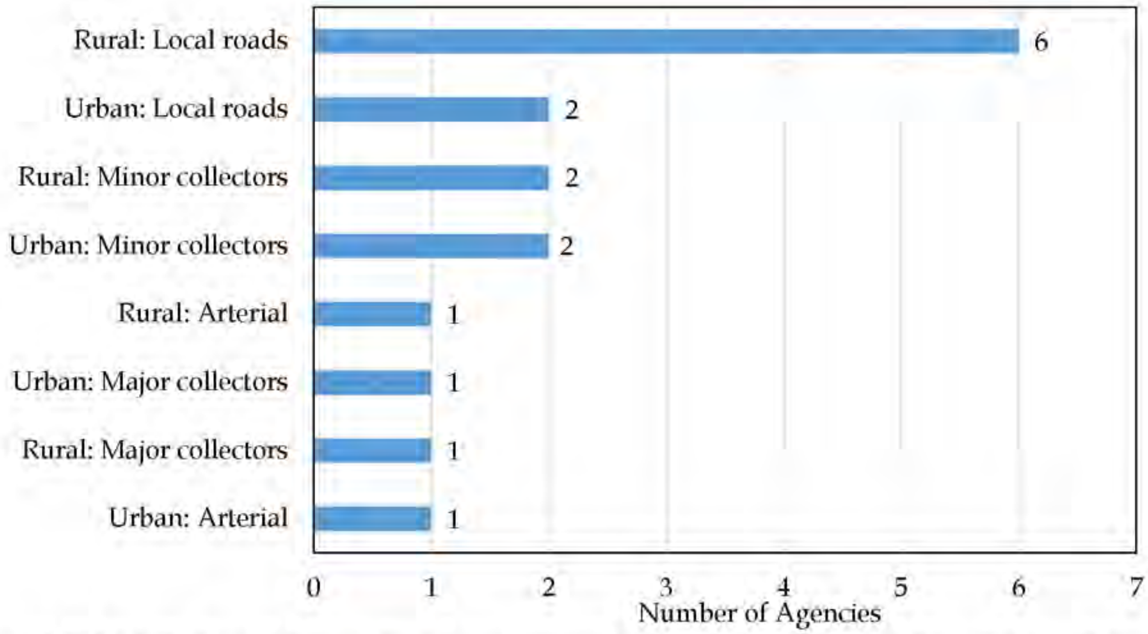

Figure 2-25 Distribution of Responding Agencies and the Roadway Types that They Treat with Fog Seals

As displayed in Figure 2-26, 58% (7/12) of responding agencies reported that they never apply fine aggregate with the asphalt material during asphalt fog sealing applications, whereas 17% (2/12) reported that they always apply fine aggregate with the asphalt material during asphalt fog sealing applications. Other agencies reported that their decision of when to apply fine aggregate with the asphalt material is dependent on factors such as the existing distresses in the pavement, the functional class of the roadway, or those outlined in Table 2-13.

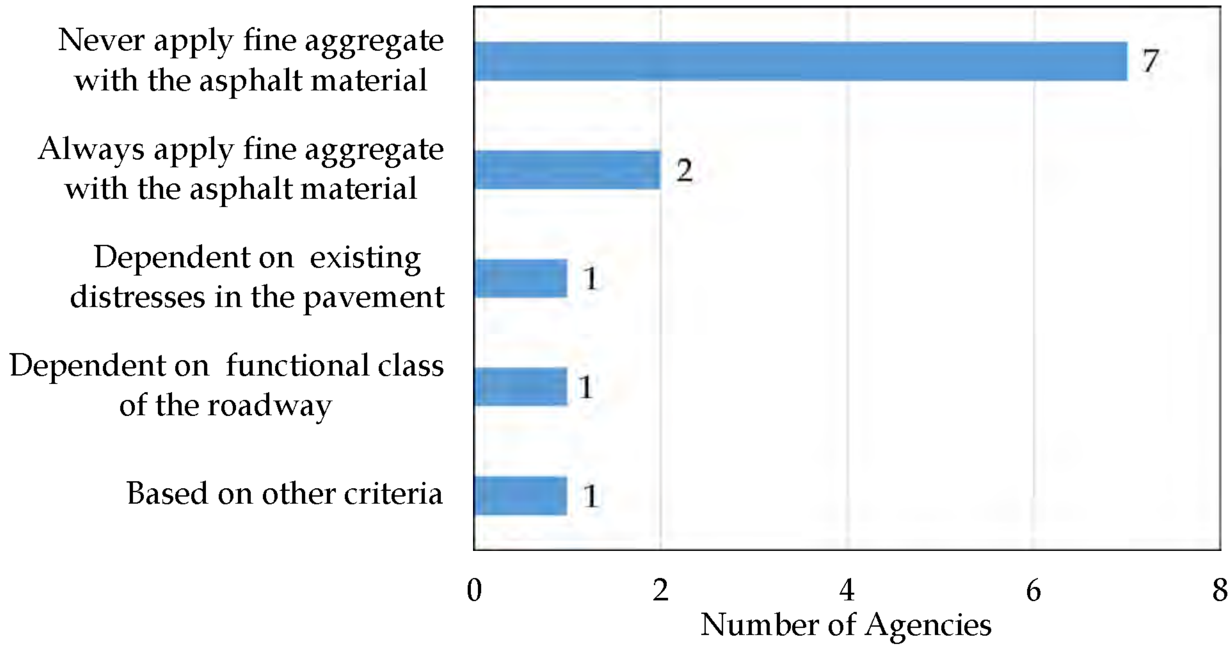

Figure 2-26 Distribution of Responding Agencies Regarding How They Determine When to Apply Fine Aggregate in Addition to the Asphalt Material During Fog Seal Applications (number of responses = 12)

Table 2-13 Agency Reported "Other" Regarding How They Determine when to Apply Fine Aggregate in Addition to the Asphalt Material During For Seal Applications

We always apply to stand-alone fogs, never on top of seal coat roads

Figure 2-27**Error! Reference source not found.** shows that for the majority of responding agencies, 42% (5/12) reported that their contractors determine the asphalt and/or fine aggregate application rates during fog seal applications. In comparison, 8% (1/12) of agencies reported that they determine their application rates using their agency-specific design method on a project-by-project basis, and 17% of responding agencies determined their application rates, and they keep them constant for all asphalt fog sealing applications conducted by their agency.

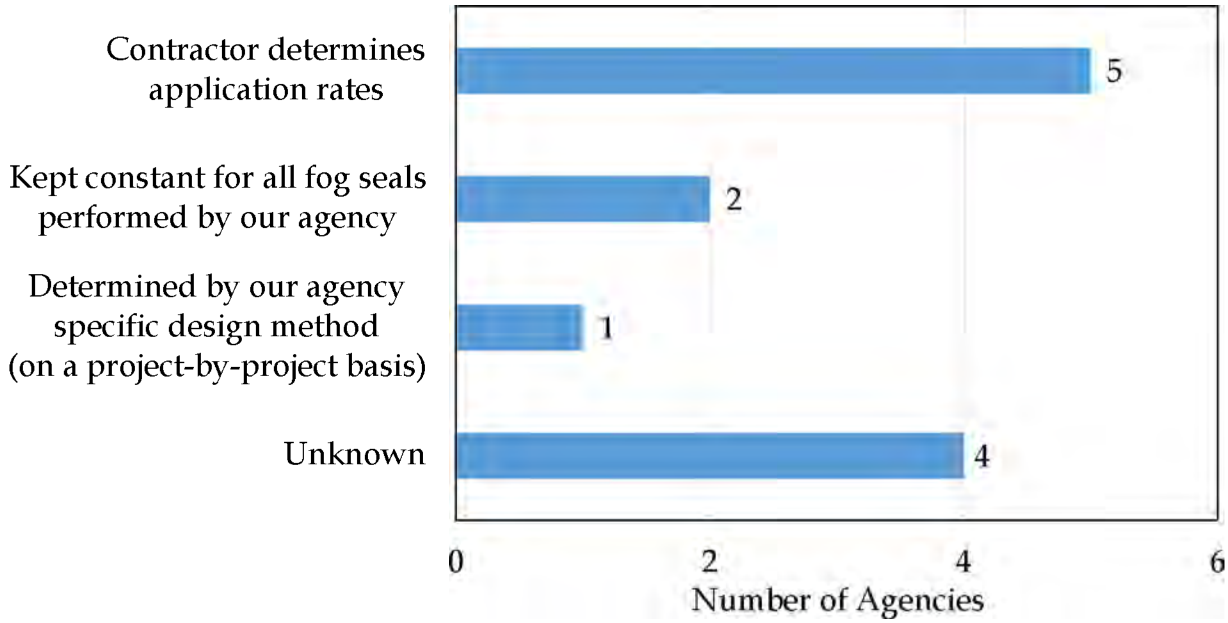

Figure 2-27 Distribution of Responding Agencies Regarding How They Determine the Asphalt and/or Fine Aggregate Application Rates for Fog Sealing Applications (number of responses = 12)

Further, as shown in Figure 2-28, 17% (2/12) of responding agencies reported that they have determined a timing process for their fog seal applications that they keep constant for all of their applications, while 42% (5/12) reported that their agency determines application timings on a project-by-project basis. The remaining 42% (5/12) of agencies reported that the timings for the application of an asphalt fog seal are determined by the contractors.

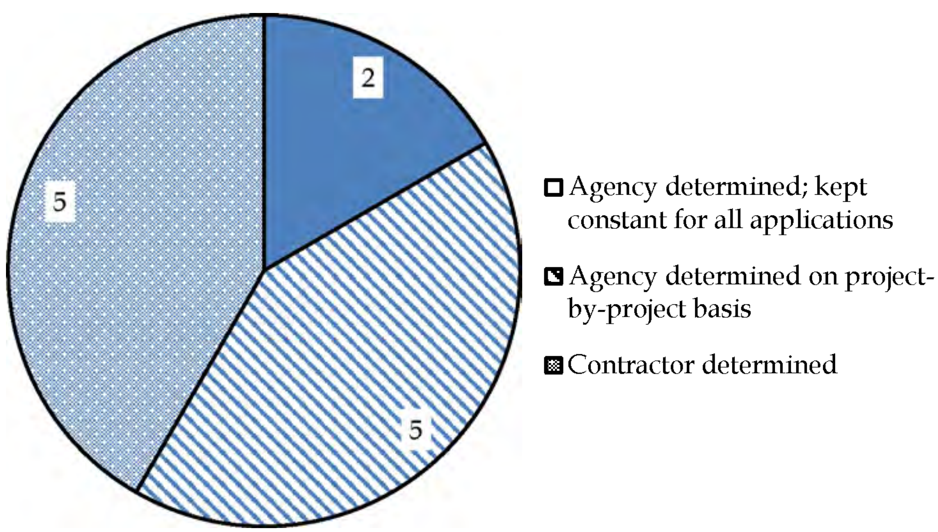

Figure 2-28 Distribution of Responding Agencies Regarding How Application Timings during Asphalt Fog Seals are Determined by their Agency (number of responses = 12)

After an asphalt fog seal is applied to a roadway, agencies must also determine when they allow traffic to drive on the treated pavement. Figure 2-29 shows that 17% (2/12) of the agencies reported that they immediately permit traffic to drive on the pavement after a seal coating application. 42% (5/12) of responding agencies noted that they allow traffic back on the roadway after a certain amount of time. Additional methods reported by the agencies for when they permit traffic to travel on a pavement that has had an asphalt fog seal applied to it is displayed in Table 2-14.

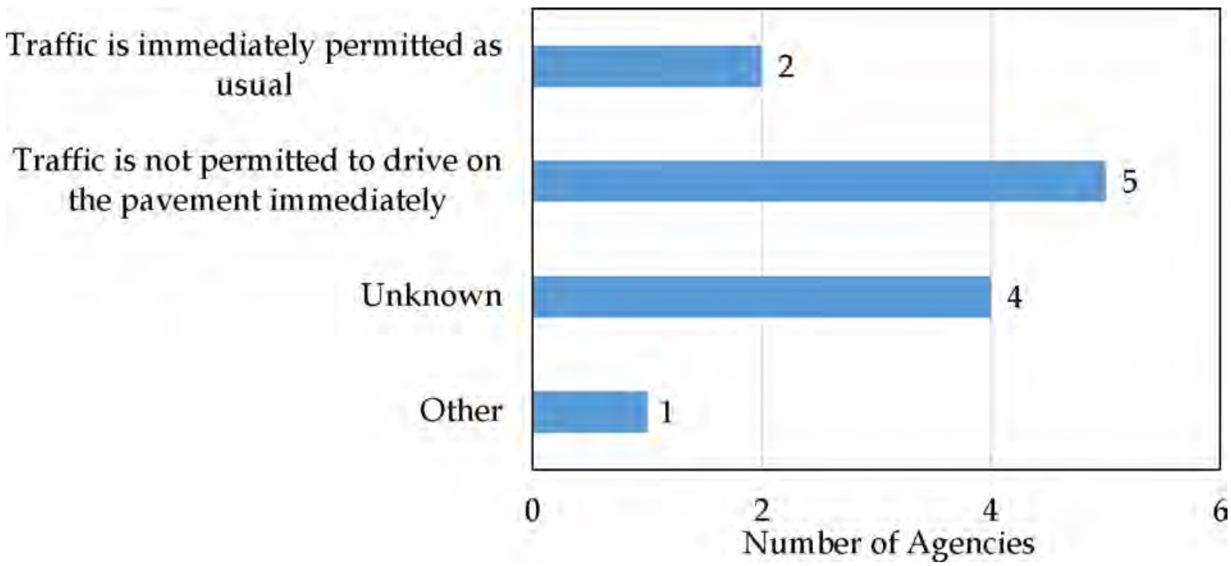

Figure 2-29 Distribution of Responding Agencies Regarding When Traffic is Permitted on a Pavement After an Asphalt Fog Seal Application (number of responses = 12)

Table 2-14 Agency Reported "Other" Regarding When Traffic is Permitted on a Pavement After an Asphalt Fog Seal Application

No traffic is permitted on the pavement until the fog seal is cured. Timing depends on weather conditions.

Of the 10 agencies that reported that they do not immediately allow traffic on the roadway, 60% (6/10) reported that they allow traffic to resume as usual at normal speeds on the treated surface after less than 2 hours, as shown in Figure 2-30. 10% (1/10) reported that they allow normal traffic after 2 to 4 hours, and another 10% (1/10) reported that they allow normal traffic after 5 to 6 hours of the fog sealing application. Additional time frames reported by the agencies are shown in Table 2-15.

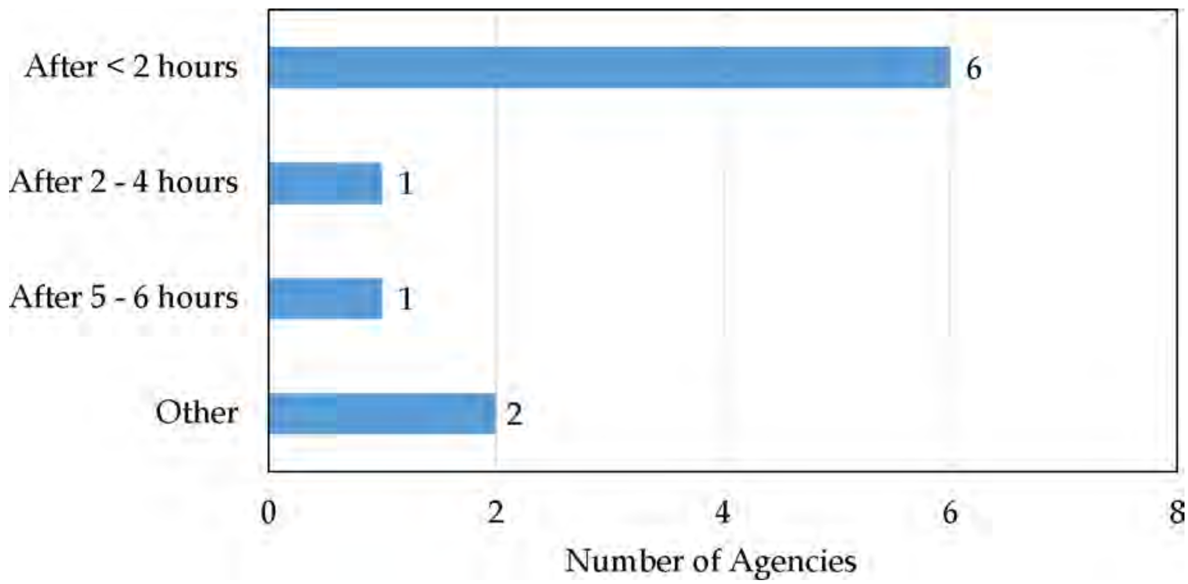

Figure 2-30 Distribution of Responding Agencies Regarding when the Allow Traffic to Resume at Normal Speeds After a Fog Sealing Application (number of responses = 10)

Table 2-15 Agency Reported "Other" with Respect to When They Allow Traffic to Resume at Normal Speeds After a Fog Sealing Applications

I am not sure. We only used fog seal one time and was not at all happy with the results.
1 hour

Figure 2-31 shows that the majority (50%, 6/12) of responding agencies reported that they expect their fog-sealing treatments to have a life expectancy of four to six years, while 17% (2/12) reported that they expect their fog seals to last three or fewer years, and 8% (1/12) expect theirs to last 7 to 9 years. Additional time frames of life expectancies reported by responding agencies are shown in Table 2-16.

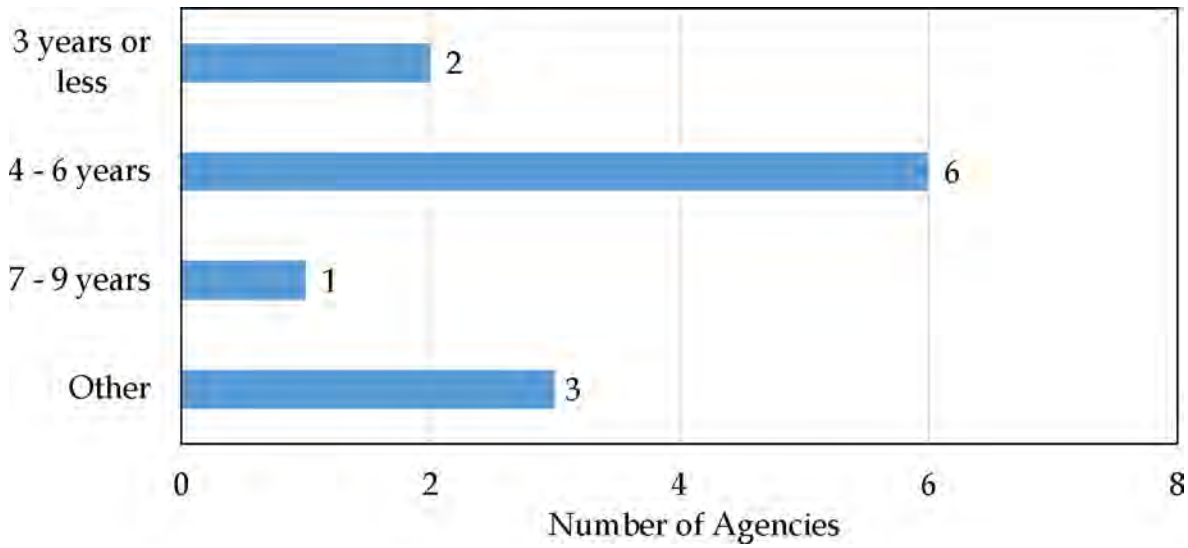

Figure 2-31 Distribution of Responding Agencies Regarding How Long They Expect a Fog Sealing Treatment Life Expectancy to be (number of responses = 12)

Table 2-16 Agency Reported 'Other' Regarding How Long They Expect a Fog Sealing Treatment Life Expectancy to be

Unknown as of now
It did NOT hold up well.
Done in conjunction with a seal coat so 4 – 7 years

As shown in Figure **2-32**, 17% (2/12) report that, in general, their asphalt fog seal applications do not fail before their expected life. 8% (1/12) of agencies reported that their fog seals fail prematurely due to traffic being permitted on the surface before proper curing of the treatment has occurred, and an additional 8% (1/12) of agencies reported that their premature failures are due to factors that they are unable to prevent (such as weather or unexpected increases in regularly experienced traffic. Lastly, 67% (8/12) of the responding agencies stated that they do not know the primary cause of premature failures of asphalt fog seals implemented by their agencies.

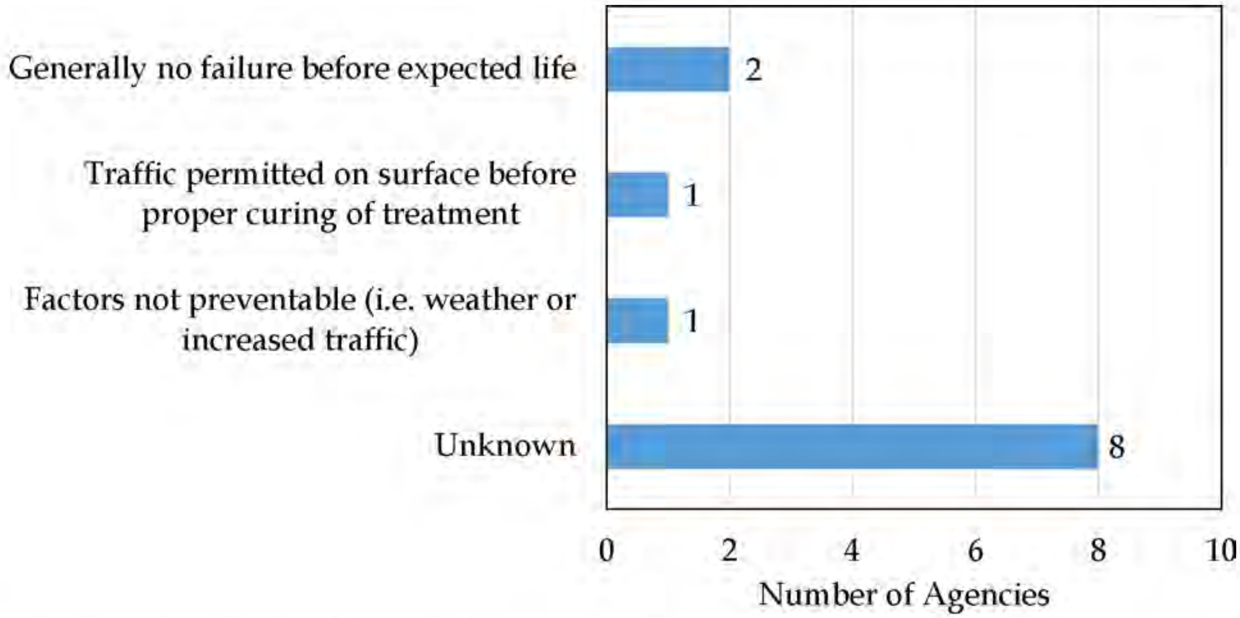

Figure 2-32 Distribution of Responding Agencies Regarding the Most Common Cause of Failures in Asphalt Fog Seal Applications Implemented by their Agency (number of responses = 12)

2.4 STATE-OF-THE-PRACTICE RELATED TO ASPHALT SURFACE TREATMENTS

Of the agencies that reported implementing asphalt surface treatments on their pavements, 65% (13/20) reported that over the last five years, they have carried out less than five surface treatment applications per year, as shown in Figure 2-33. 30% (6/20) of the responding agencies reported carrying out 5 to 10 applications per year, while 5% (1/20) conduct more than 20 asphalt surface treatment applications per year.

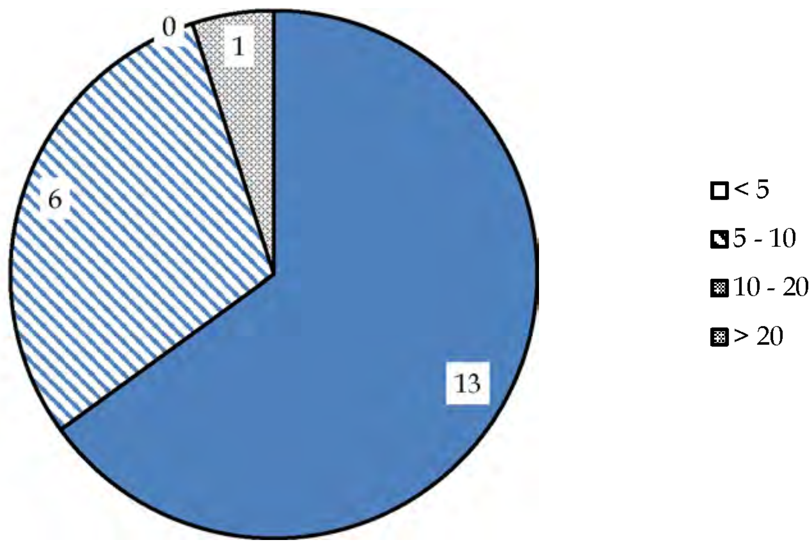

Figure 2-33 Distribution of Responding Agencies and the Number of Asphalt Surface Treatment Applications They Have Carried Out Per Year (over the last 5 years) (number of responses = 20)

As shown in Figure 2-34, the primary distresses that the responding agencies aim to delay or prevent by implementing asphalt surface treatments is fatigue (alligator) cracking, followed by transverse cracking, longitudinal cracking, and raveling and loss of skid resistance. Other distresses that the responding agencies reported preventing using asphalt surface treatments were block cracking, bleeding, and rutting, in addition to those presented in Table 2-17.

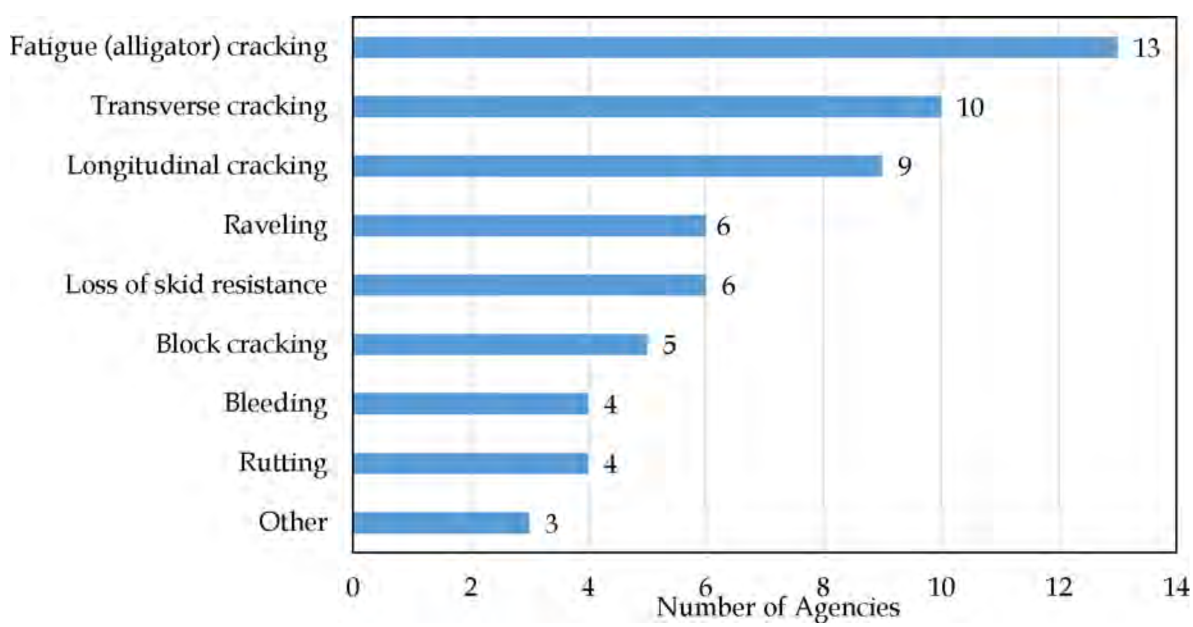

Figure 2-34 Distribution of Responding Agencies and the Distress(es) They Aim to Delay or Prevent by Implementing Asphalt Surface Treatments

Table 2-17 Agency Reported "Other" Regarding the Distress(es) They Aim to Delay or Prevent by Implementing Asphalt Surface Treatments

Sealing gravel roads for dust control and to prevent loss of aggregate by traffic and snow plowing
Pothole
Road is exceptionally bad

Figure 2-35 displays the roadway types (or functional classes of the pavements that the responding agencies treat with asphalt surface treatments. Per the survey results, asphalt surface treatments are most commonly carried out on rural local roads, followed by urban local roads and rural minor collectors. Responding agencies also reported applying asphalt surface treatments to rural arterials, urban minor collectors, and rural major collectors.

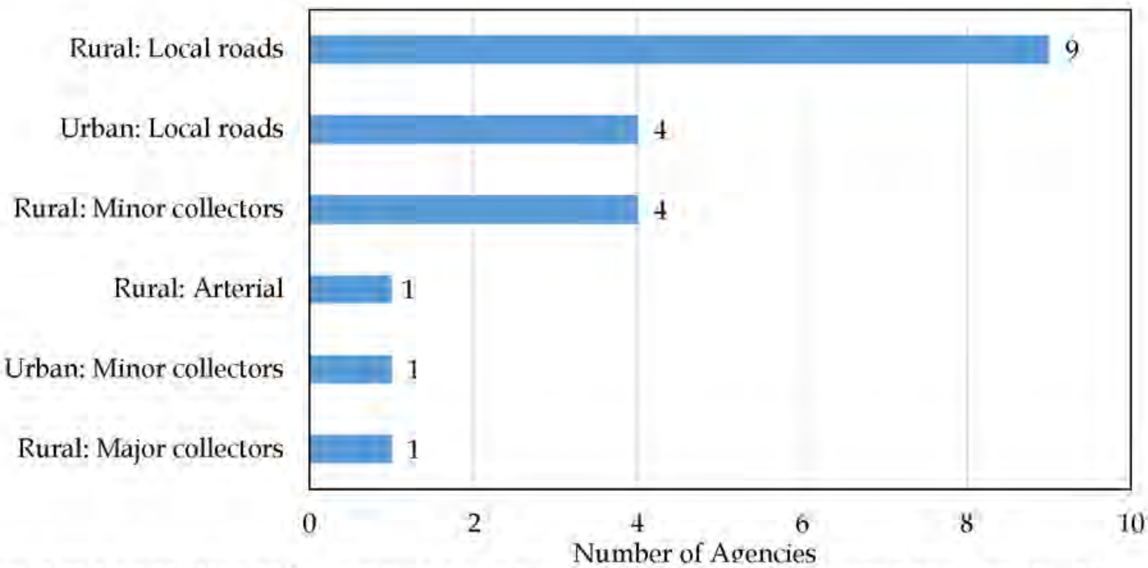

Figure 2-35 Distribution of Responding Agencies and the Roadway Types that They Treat with Asphalt Surface Treatments

As per the definitions provided in the introduction of this report, an asphalt surface treatment is essentially two asphalt seal coating applications applied on top of each other. 81% (17/21) of agencies that implement surface treatments reported that the primary reason that they will implement an asphalt surface treatment over a seal coat is based on the existing condition of the roadway, such as existing distresses, as shown in Figure 2-36. 10% (2/21) of agencies reported that they base their choice on the functional class of the roadway, while other agencies reported other reasons they consider, as shown in Table 2-18.

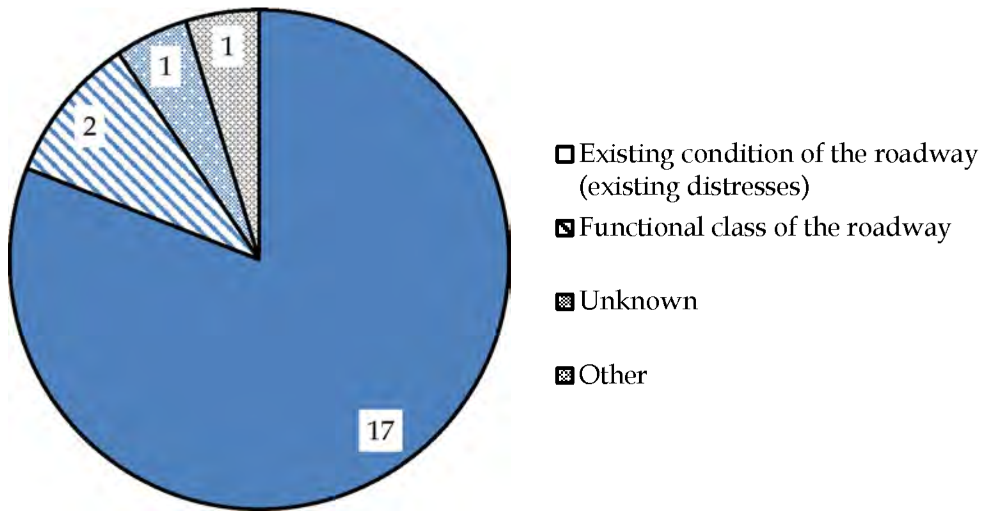

Figure 2-36 Distribution of Responding Agencies Regarding the Primary Reason their Agency Implements Asphalt Surface Treatments over Asphalt Seal Coats (number of responses = 21)

Table 2-18 Agency Reported "Other" with Respect to the Primary Reason their Agency Implements Asphalt Surface Treatments over Asphalt Seal Coats

On gravel roads with minimal traffic we prepare proper leveling and compacted base and apply Asphalt Surface Treatment vs paving due to cost.

As shown in Figure 2-37, 29% (6/21) of responding agencies reported that they apply the second application of an asphalt surface treatment within 1 hour of the first application, while an additional 29% (6/21) reported that they perform the second application within 2 to 3 hours of the first. 5% (1/21) of agencies apply the second application 4 to 5 hours after the first, while 24% (5/21) of agencies reported that they do not apply the second application until more than 1 day after the first. Additional responses from the agencies regarding the timing between the first and second applications of asphalt surface treatments are shown in Table 2-19.

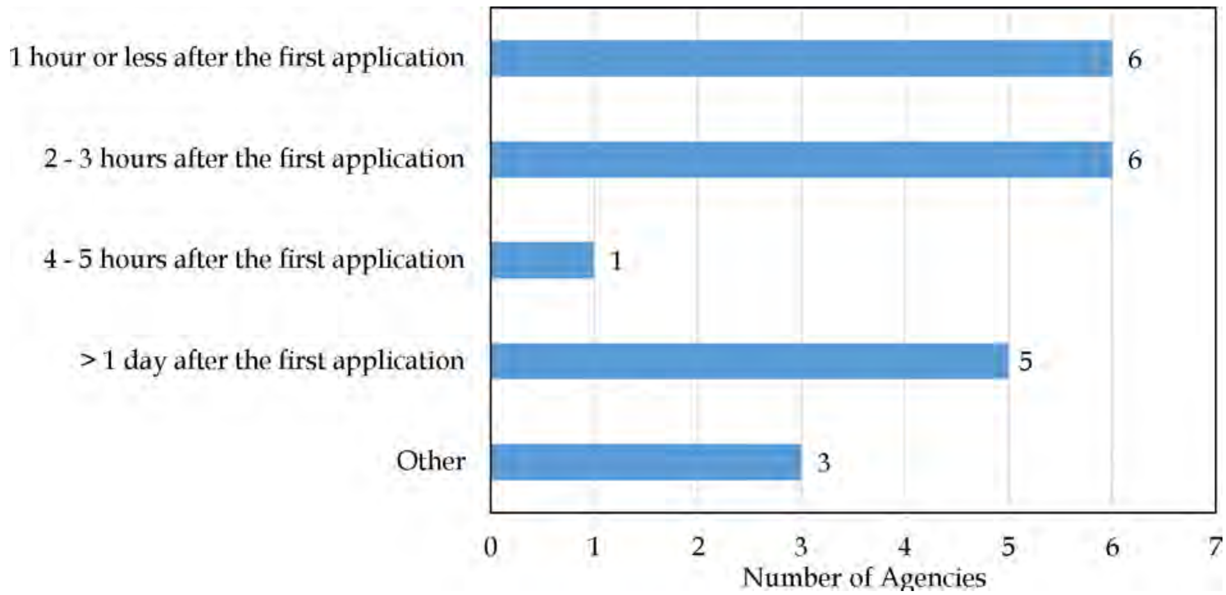

Figure 2-37 Distribution of Responding Agencies Regarding the Amount of Time between the First and Second Applications of an Asphalt Surface Treatment is Generally Applied (number of responses = 21)

Table 2-19 Agency Reported "Other" with Respect to the Amount of Time between the First and Second Applications of an Asphalt Surface Treatment is Generally Applied

Unknown
Unknown
Determined by contractor

As displayed in Figure 2-38**Error! Reference source not found.**, 43% (9/21) of the responding agencies reported that the mix design and the asphalt and aggregate application rates for an asphalt surface treatment application are determined by the contractors, while 33% (7/21) reported that their agency determines the application rates and mix design bases on an agency-specific mix design method, and 14% (3/21) reported that they keep the application rates and mix design constant for all projects implemented by their agency. Additional methods for determining application rates and mix designs were reported by responding agencies as shown in Table 2-20.

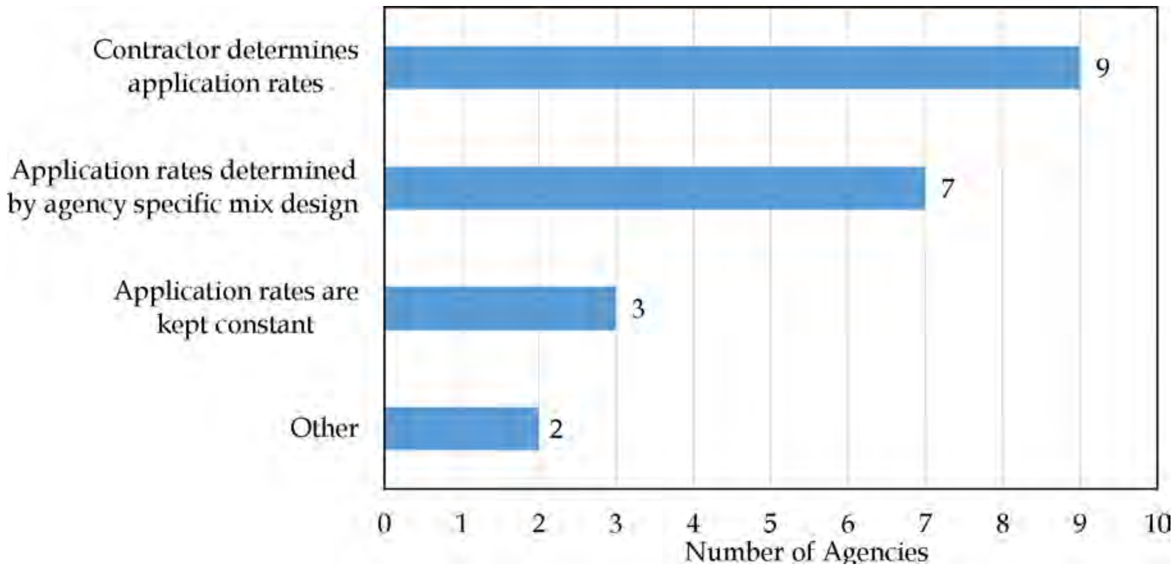

Figure 2-38 Distribution of Responding Agencies Regarding How They Determine the Asphalt and Aggregate Application Rates/Mix Design for an Asphalt Surface Treatment Application (number of responses = 21)

Table 2-20 Agency Reported "Other" with Respect to How They Determine the Asphalt and Aggregate Application Rates/Mix Design for an Asphalt Surface Treatment Application

With assistance from PennDOT Municipal Services Representative.
PennDOT rule book

Per the PennDOT asphalt surface treatment specification, many types of emulsified asphalt material are allowable for these applications. The responding agencies reported that from the allowable list, they select which of the allowable types to use based on a range of factors, as shown in Figure 2-39. The choice of emulsified asphalt material is most commonly based on past performance, followed by cost. Many agencies also reported that contractors determine the type of emulsified asphalt to be used. In addition, agencies reported that they determine the type based on the availability of material, historical use, and project needs (such as the functional class of the roadway, etc.). Additional methods noted by the responding agencies are shown in Table 2-21.

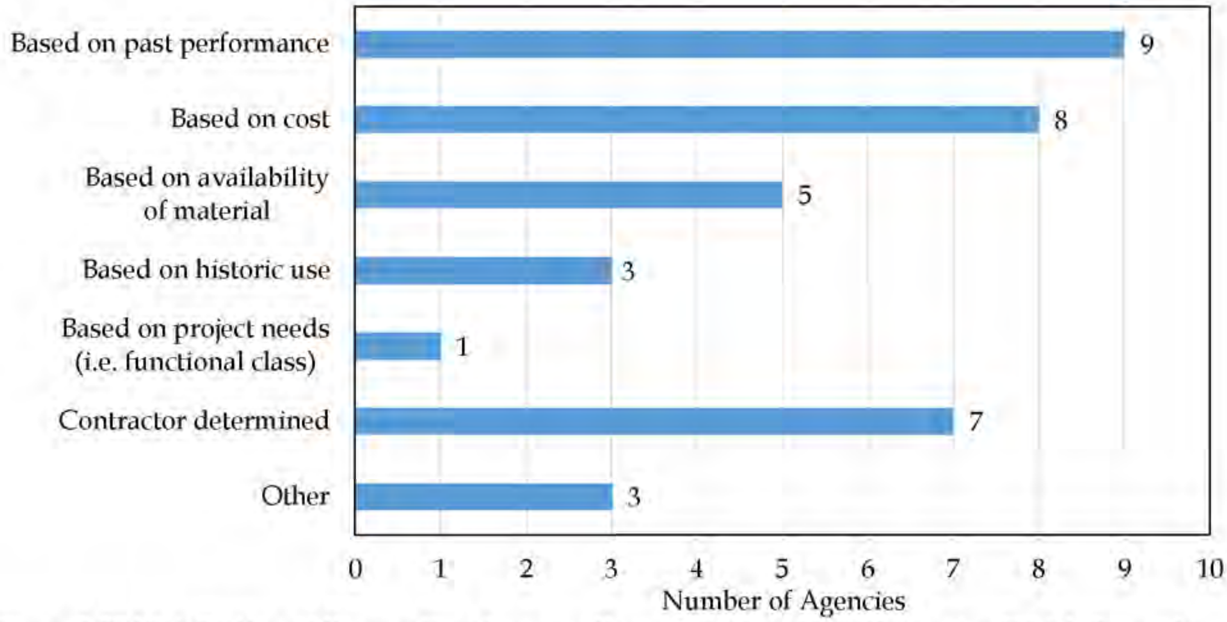

Figure 2-39 Distribution of Responding Agencies Regarding How They Determine Which Type of Emulsified Asphalt Material to Use in an Asphalt Surface Treatment Application (number of responses = 20)

Table 2-21 Agency Reported "Other" Regarding How They Determine Which Type of Emulsified Asphalt Material to use in an Asphalt Surface Treatment Application

With assistance from PennDOT Municipal Services Representative.
PennDOT rule book
Municipal Services Specialist

The PennDOT specification also noted that washed aggregate, precoated aggregate, or recycled asphalt pavement could be used as aggregate material in asphalt surface treatment applications. The majority of agencies reported that they use only washed aggregate in their applications, as shown in Figure 2-40, while only 3 out of 21 agencies reported that they use precoated aggregate in these applications. None of the responding agencies reported using RAP in asphalt surface treatments. Of the three agencies that reported that they use precoated aggregate in asphalt surface treatment applications, they each reported different factors that influence their decision to use precoated over non-precoated aggregate, as shown in Figure 2-41. Each of the agencies reported one of the following factors: based on the properties of the aggregate that is being used, based on the functional class of the roadway, and based on the existing distresses present in the pavement.

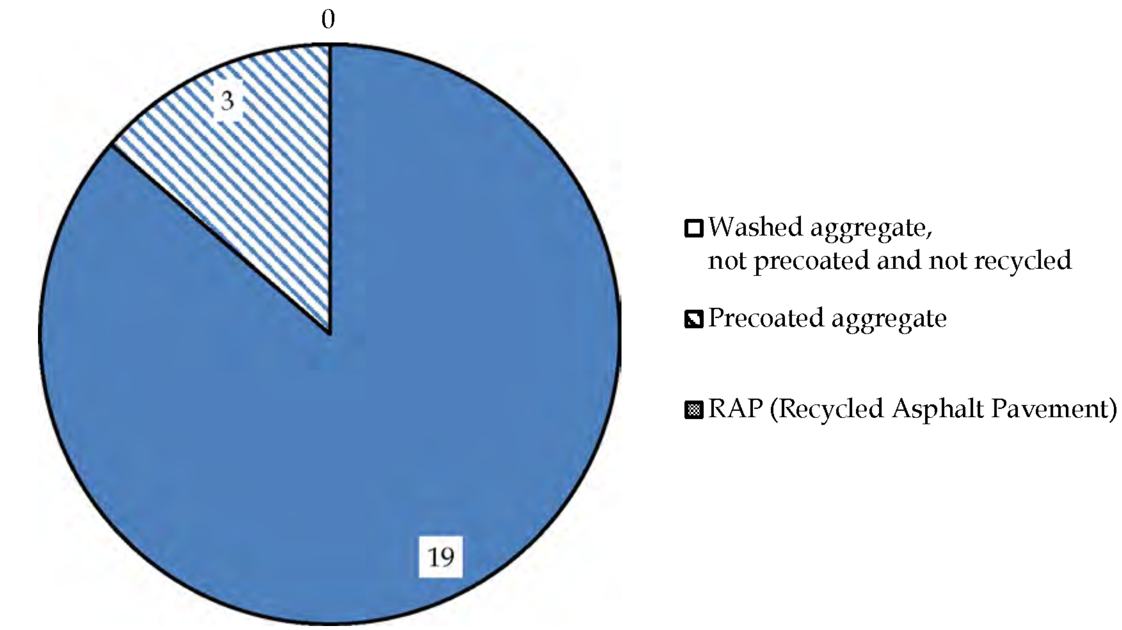

Figure 2-40 Distribution of Responding Agencies Regarding the Type of Aggregate They Use in Asphalt Surface Treatment Applications (number of responses = 21)

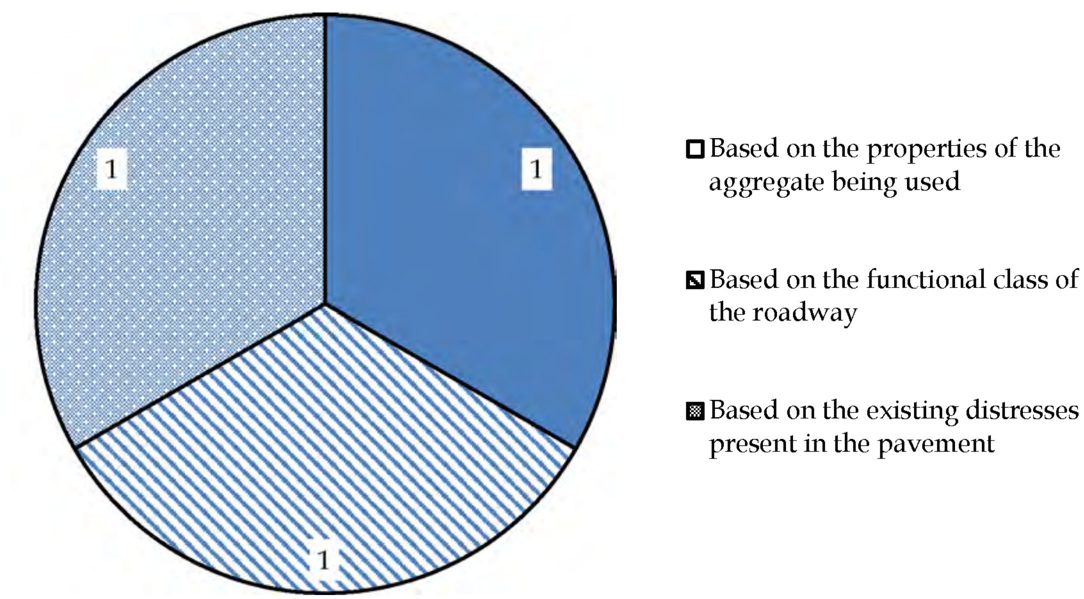

Figure 2-41 Distribution of Responding Agencies Regarding Factors that Influence Agency's Decision to Use Precoated Aggregate in Place of Not Precoated Aggregate during an Asphalt Surface Treatment Application (number of responses = 3)

In addition to the materials used during these preservation treatments, the construction process and application timings are also important. As shown in Figure 2-42, 29% (6/21) of agencies reported that they have determined a timing process that they keep constant for all of their applications, while 24% (5/21) reported that their agency determines timings on a project-by-project basis. Despite that, the majority of responding agencies (48%, 10/21) reported that the timings for the application of an asphalt surface treatment are determined by the contractors.

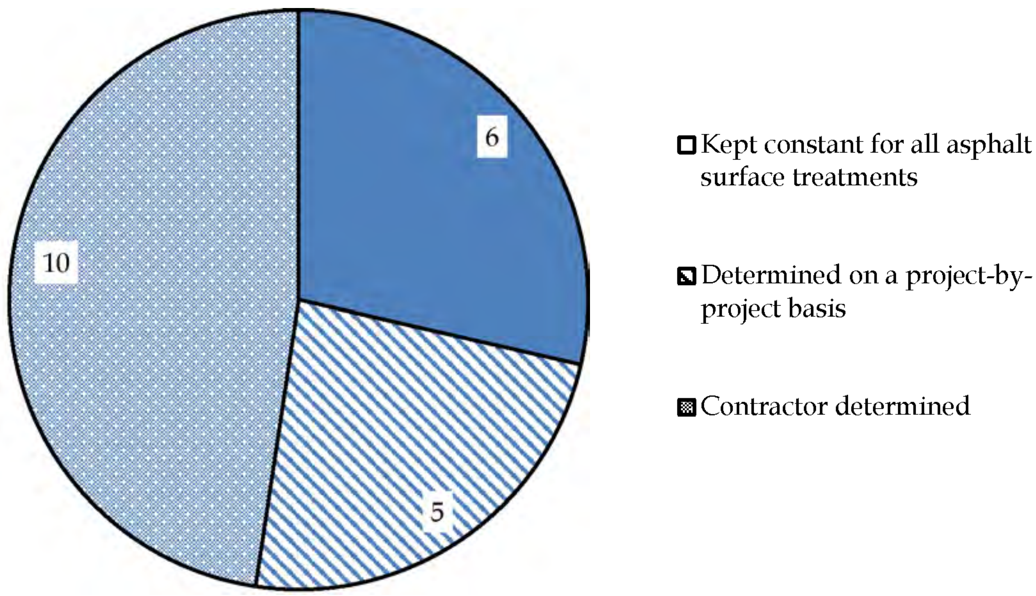

Figure 2-42 Distribution of Responding Agencies Regarding How They Determine Application Timings During the Construction of an Asphalt Surface Treatment (number of responses = 21)

60% (12/20) of responding agencies stated that the contractors determine the amount of time between the first and second asphalt and aggregate applications in an asphalt surface treatment, as shown in Figure 2-43. 25% (5/20) of agencies reported that their agency has determined a standard amount of time between the first and second applications, while 5% (1/20) stated that they determine it based on the percent embedment of the first application, and another 5% (1/20) bases the timing on additional factors. Other factors described by the responding agencies to determine the time between the first and second applications of an asphalt surface treatment are displayed in Table 2-22.

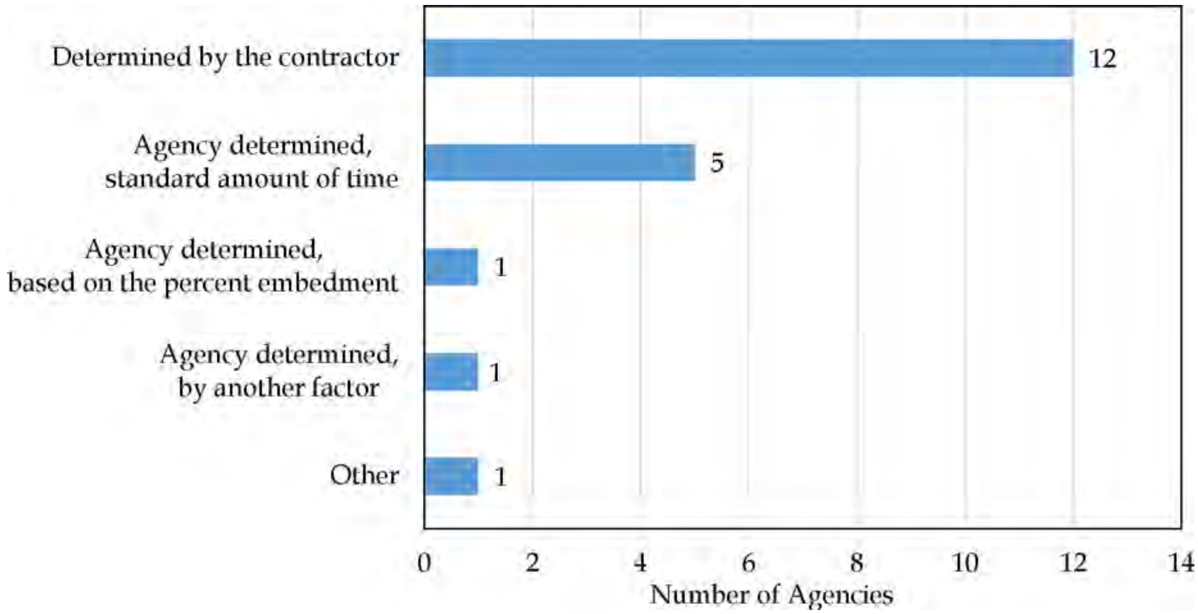

Figure 2-43 Distribution of Responding Agencies with Respect to How They Determine When the Second Application of Asphalt and Aggregate Can be Applied During an Asphalt Surface Treatment Application (number of responses = 20)

Table 2-22 Agency Reported "Other" with Respect to How They Determine When the Second Application of Asphalt and Aggregate Can be Applied During an Asphalt Surface Treatment Application

First application must be cured and swept prior to second application.

After an asphalt surface treatment application is performed on a roadway, agencies must also determine when they allow traffic to drive on the treated pavement. Figure 2-44 shows that 65% (13/20) of the agencies reported that they immediately permit traffic to drive on the pavement after a seal coating application. 10% (2/20) of responding agencies noted that they immediately allow traffic to resume on the pavement but only following a pilot car at the speeds reported in Table 2-23. Another 15% (3/20) of the responding agencies reported that they allow traffic back on the roadway after a certain amount of time, as detailed in Table 2-20.

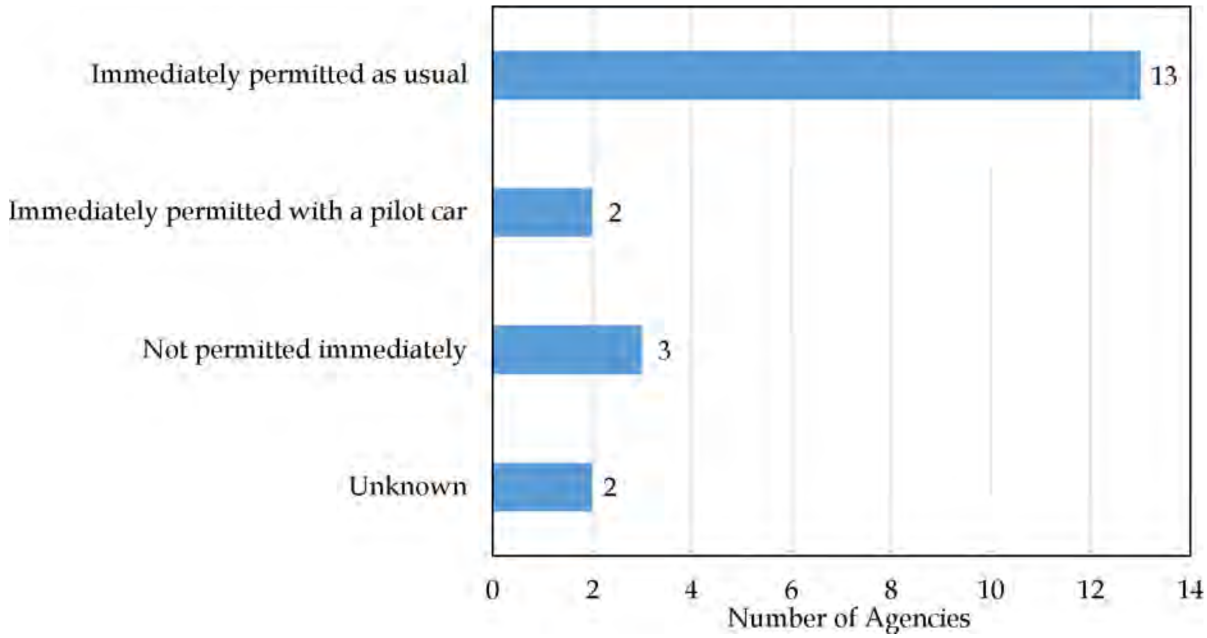

Figure 2-44 Distribution of Responding Agencies Regarding When Traffic is Permitted to Drive on a Pavement After the Application of an Asphalt Surface Treatment (number of responses = 20)

Table 2-23 Agency Reported "Speed" That Their Pilot Car Travels at After an Asphalt Surface Treatment Application

No set speed. Pilot Vehicle safely navigates traffic.
Posted speed limit.

Of the 7 agencies that reported that they do not immediately allow traffic on the roadway at usual after an asphalt surface treatment application, 19% (2/7) reported that they allow traffic to resume as usual at normal speeds on the treated surface after less than 2 hours as shown in Figure 2-45. Another 19% (2/7) reported that they allow the usual traffic on the treated pavement after two to four hours, and another 19% (2/7) reported that they do not allow usual traffic on the treated surface until after 5 to 6 hours. Additional responses regarding when traffic is allowed on an asphalt surface treatment are shown in Table 2-24.

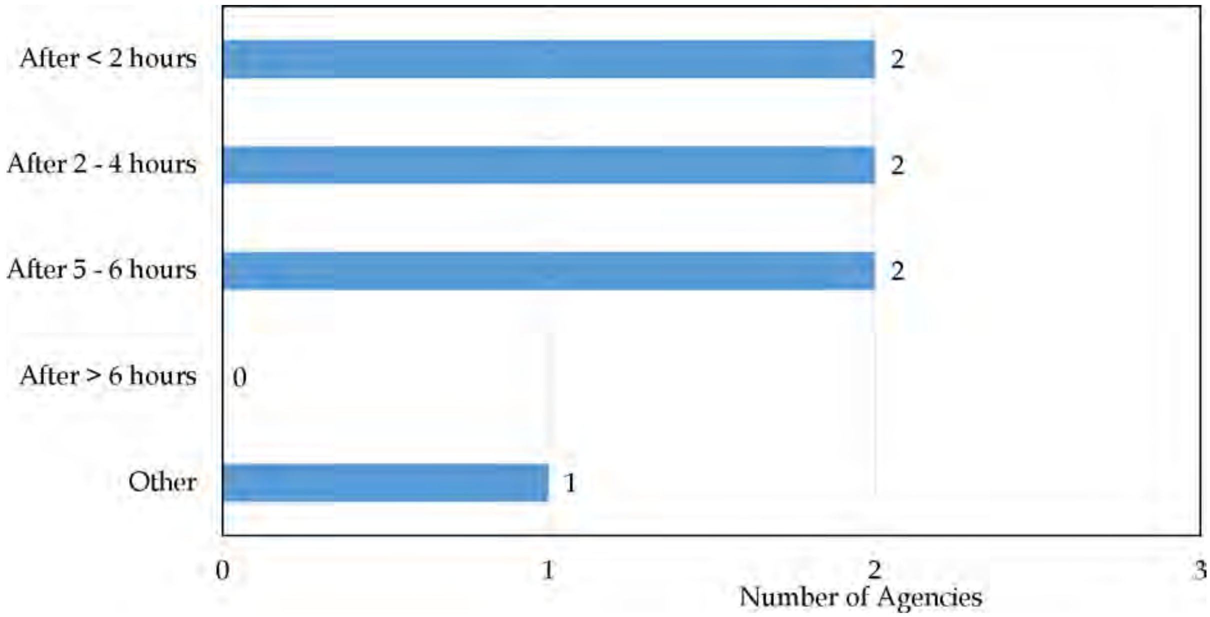

Figure 2-45 Distribution of Responding Agencies with Respect to When Traffic is Able to Resume as Usual, at Normal, on the Treated Surface (number of responses = 7)

Table 2-24 Agency Reported "Other" Regarding How Long After an Asphalt Surface Treatment Application Traffic is Able to Resume at Normal on the Treated Surface

Unknown

After the application of an asphalt surface treatment, only 14% (3/21) of responding agencies reported that they perform post-construction testing to determine the percent embedment of the aggregate and the asphalt, as shown in Figure 2-46. To perform this evaluation, they reported using the methods described in Table 2-25. 67% (14/21) reported that they do not evaluate the percent embedment after construction of an asphalt surface treatment, while the remaining 19% (4/21) reported that they were unknown if their agency evaluates percent embedment after asphalt surface treatment applications.

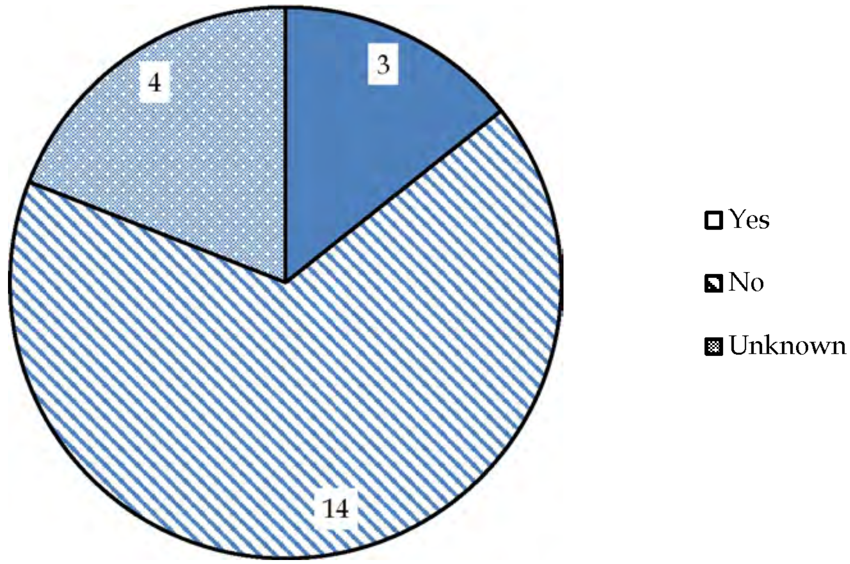

Figure 2-46 Distribution of Responding Agencies with Respect to if They Perform Post-Construction Testing to Determine the Percent Embedment of the Aggregate in the Asphalt (number of responses = 21)

Table 2-25 Agency Reported Method Used to Determine Post-Construction Percent Embedment of the Aggregate in the Asphalt

Visual
Randon manual probing
Visual test looking at embedment

Figure 2-47 shows that the majority (57%, 12/21) of responding agencies reported that they expect their asphalt surface treatments to have a life expectancy of four to six years, while 29% (6/21) reported life expectancies of 7 to 9 years. 5% (1/21) reported that their agency expects asphalt surface treatments to last at least 10 years. Additional time frames of life expectancies reported by responding agencies are shown in Table 2-26.

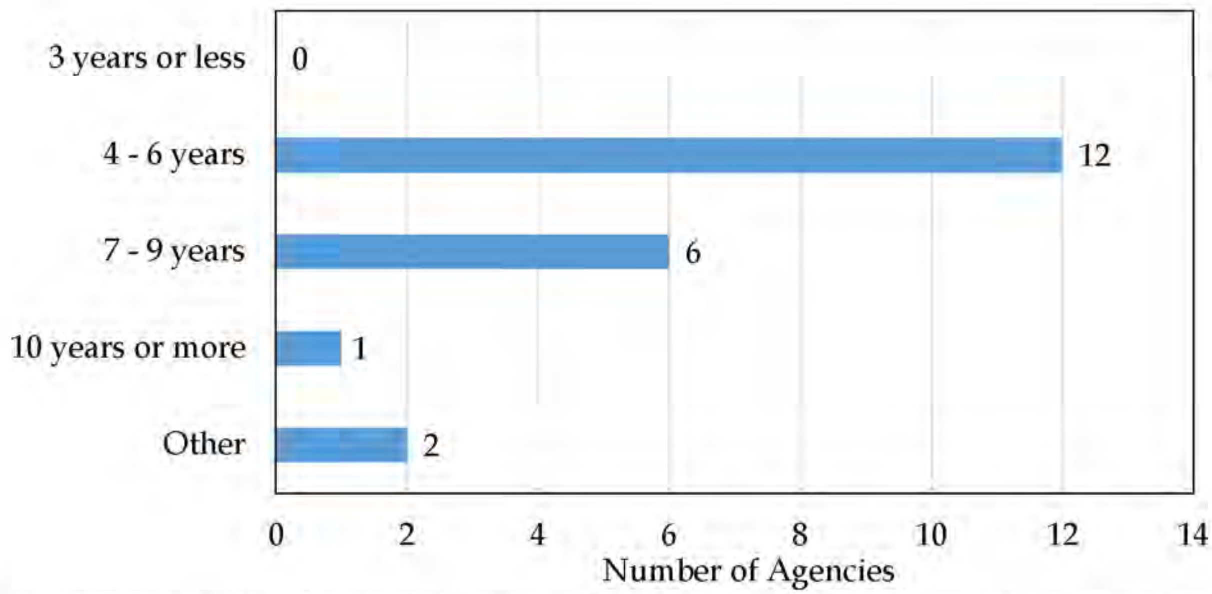

Figure 2-47 Distribution of Responding Agencies with Respect to How Long Their Agency Expects an Asphalt Surface Treatment Life Expectancy to be (number of responses = 21)

Table 2-26 Agency Reported "Other" with Respect to How Long Their Agency Expects an Asphalt Surface Treatment Life Expectancy to be

4 – 7 years

As reported by responding agencies, the most common cause of failures in asphalt surface treatments is due to distresses in the existing pavement (24%, 5/21), as shown in Figure 2-48. 19% (4/21) of agencies reported that their seal coats most generally fail due to factors that are not preventable by the mix design or construction processes, but rather due to factors such as weather or increased traffic. 10% (2/21) reported that their failures are most commonly due to there being poor quality of construction, while 5% (1/21) reported that their asphalt surface treatments generally fail due to traffic being permitted to travel on the surface before proper curing has occurred, while none of the responding agencies noted that the cause of their failing surface treatments was due to poor material selection or poor application timings. 24% (5/21) of responding agencies reported that their asphalt surface treatment applications generally do not fail before the end of their expected life. Additional asphalt surface treatment failure causes reported by responding agencies are shown in Table 2-27.

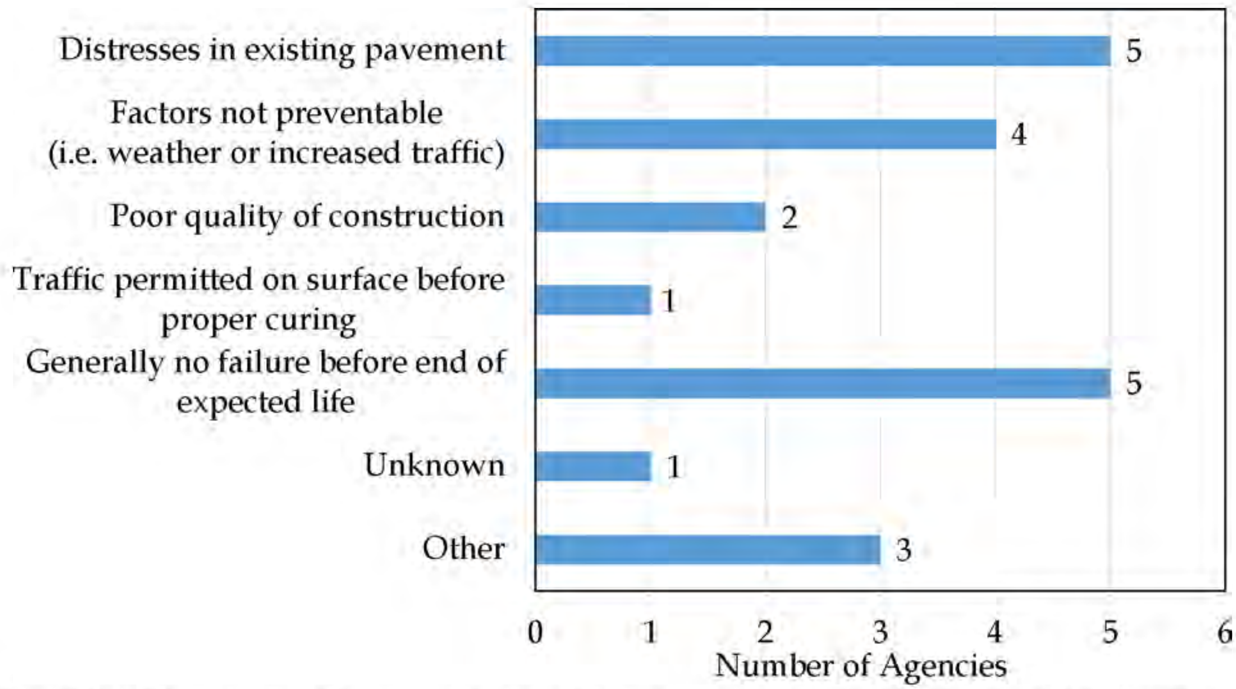

Figure 2-48 Distribution of Responding Agencies Regarding the Most Common Cause of Failures in Asphalt Surface Treatment Applications Implemented by Their Agency (number of responses = 21)

Table 2-27 Agency Reported "Other" Regarding Most Common Cause of Failures in Asphalt Seal Coat Applications Implemented by Their Agency

Weather-heavy rains, flooding
None
Existing roadway structure

2.5 STATE-OF-THE-PRACTICE RELATED TO SLURRY SEALS

Of the 3 agencies that reported implementing slurry seal treatments on their pavements, 67% (2/3) reported that over the last five years, they have carried out less than five seal coating applications per year as shown in Figure 2-49. The remaining 33% (1/3) of the responding agencies reported that they carry out 5 to 10 slurry sealing applications per year.

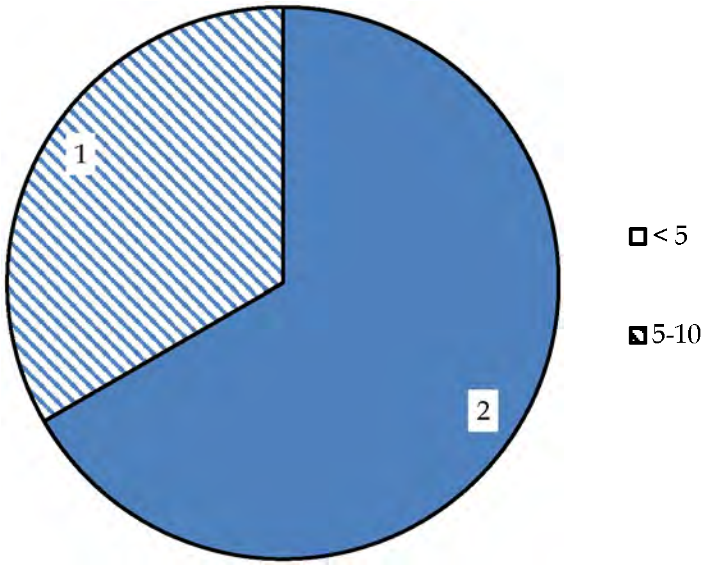

Figure 2-49 Distribution of Responding Agencies and the Number of Slurry Seal Applications They have Carried Out Per Year (over the last 5 years) (number of responses = 3)

As shown in Figure 2-50, the primary distresses that the responding agencies aim to delay or prevent by implementing slurry seals is transverse cracking, followed by longitudinal cracking and loss of skid resistance. Other distresses that the responding agencies reported preventing using slurry seals were fatigue (alligator) cracking, bleeding, raveling, and block cracking.

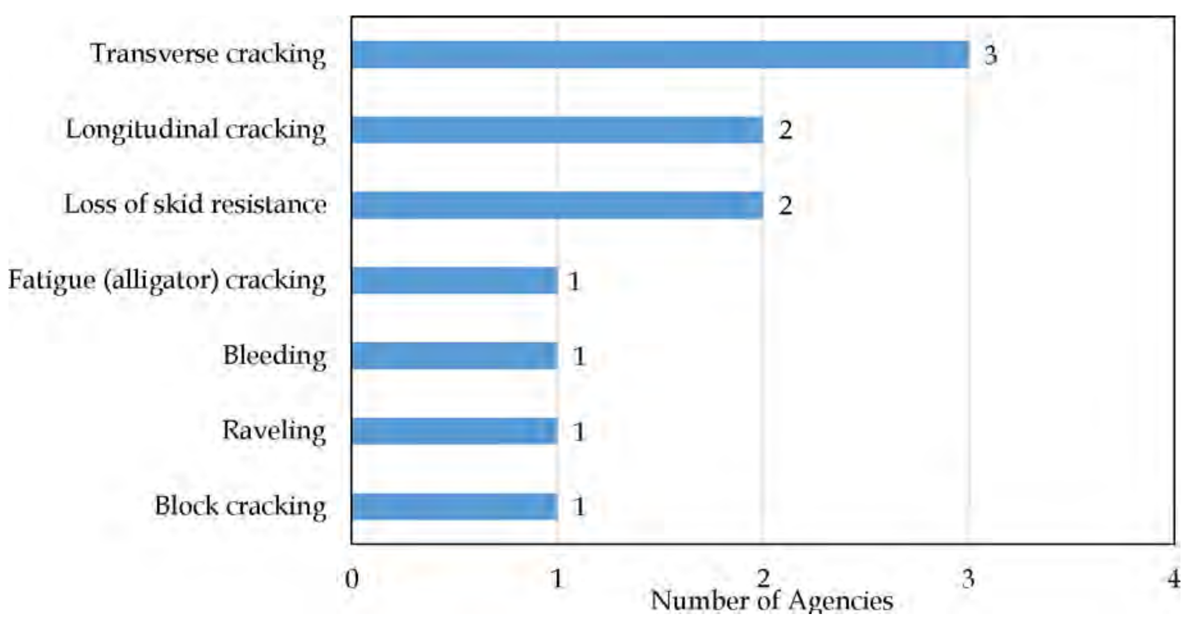

Figure 2-50 Distribution of Responding Agencies and the Distress(es) They Aim to Delay or Prevent by Implementing Slurry Seals

Figure 2-51 displays the roadway types (or functional classes) of the pavements that the responding agencies treat with slurry seals. Per the survey results, slurry seals are most commonly applied to both rural and urban local roads, along with on rural minor collectors. They are also reportedly less frequently carried out on rural arterials, urban major collectors, urban minor collectors, and urban arterials.

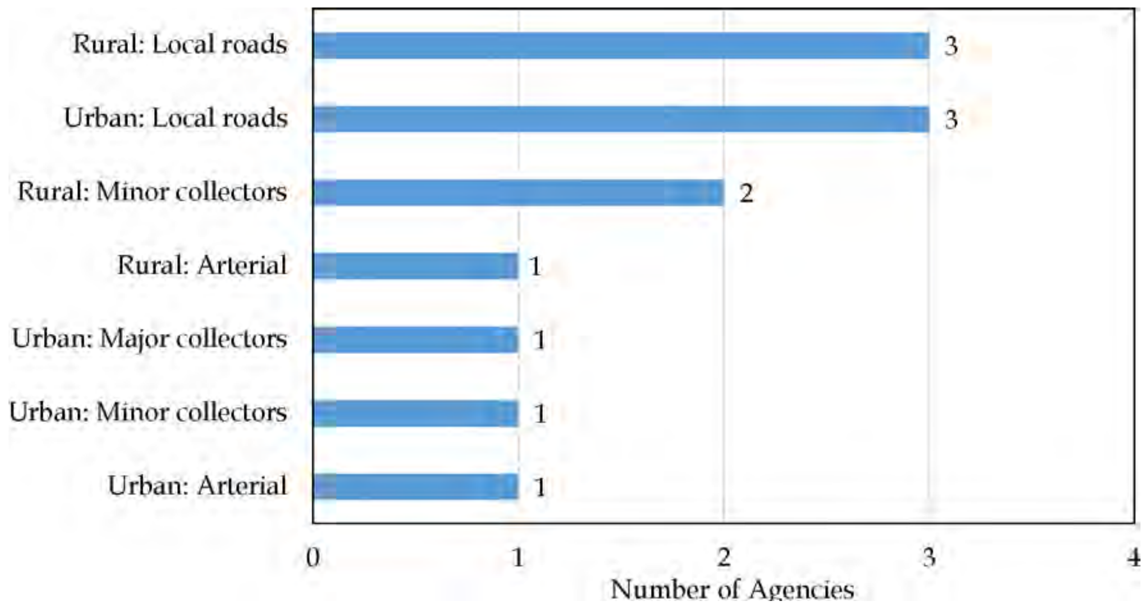

Figure 2-51 Distribution of Responding Agencies and the Roadway Types that They Treat with Slurry Seals

As per the PennDOT slurry seal specifications, there are three types of slurry seals that can be applied to a pavement, and they are as follows:

- Type I: Used to seal cracks, fill voids, and correct surface erosion
- Type II: Used to fill surface voids, correct severe surface erosion conditions, and provide a minimum wearing surface
- Type III: Used to provide a new moderate-wearing surface or to build up a crown

Figure 2-52 shows that 33% (1/3) of responding agencies reported that Type I slurry seal is their most commonly implemented of the three types, while 67% (2/3) of the agencies reported that Type II is their most commonly implemented. None of the three responding agencies reported that the Type III slurry seal is the most common type that they carry out.

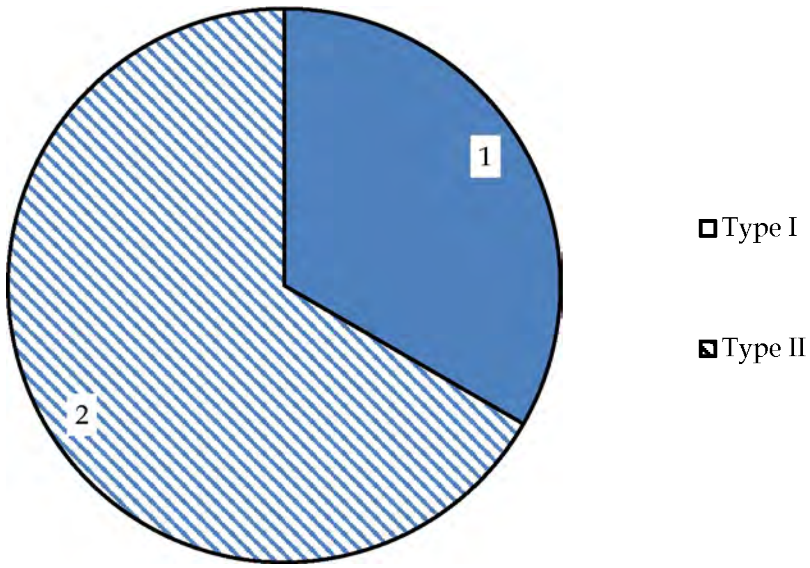

Figure 2-52 Distribution of Responding Agencies and the Most Common Type of Slurry Seal Implemented by their Agency (number of responses = 3)

Per the PennDOT specification, multiple types of asphalt material can be used in slurry seal applications. The responding agencies reported that from that list, they select which of the allowable types to use based on a range of factors, as shown in Figure 2-53. The choice of asphalt material is most commonly based on cost. Agencies also reported that contractors determine the type of asphalt to use. In addition, agencies reported that they determine the type based on past performance or historical use.

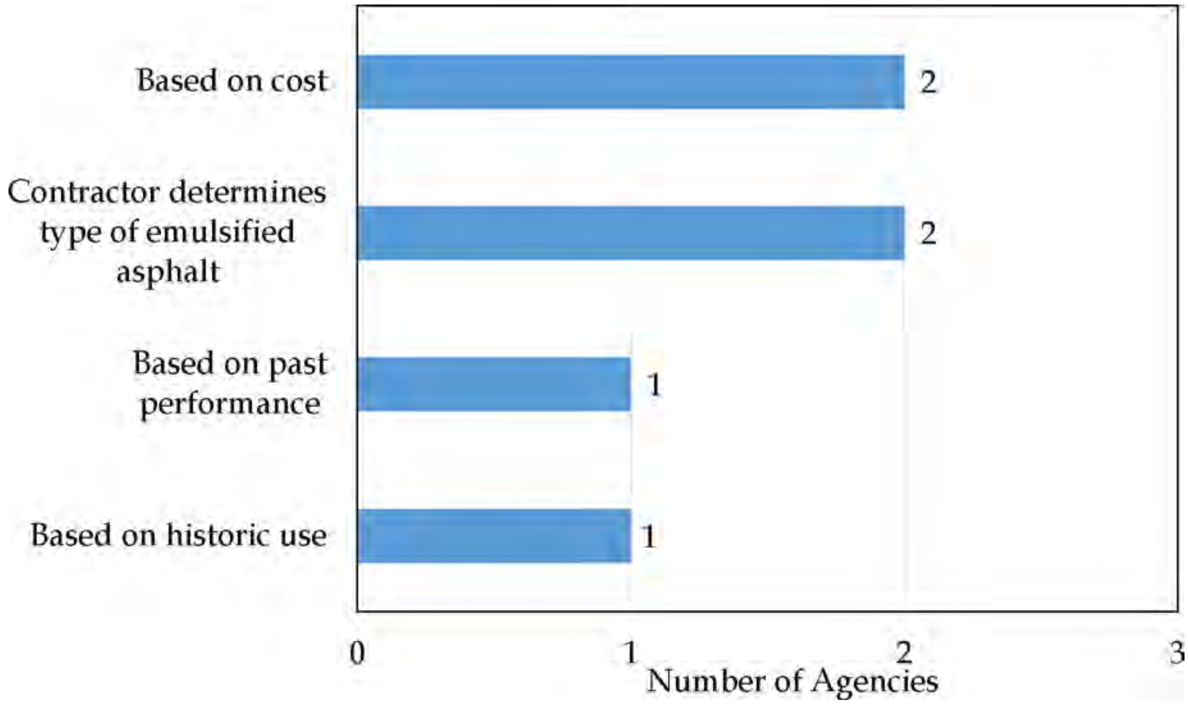

Figure 2-53 Distribution of Responding Agencies Regarding How They Determine Which Type of Emulsified Asphalt Material to Use in a Slurry Seal Application (number of responses = 3)

In addition to asphalt material, filler material is also an important material to be used in slurry seal applications. 100% (3/3) of the responding agencies reported that they have used Portland cement as the type of filler in their slurry seal applications over the past 5 years. None of the 3 responding agencies reported that they have used hydrated lime, limestone dust, or fly ash as filler in slurry seals in the last 5 years.

The mixture composition of slurry seals is reportedly determined in different ways by different agencies. 33% (1/3) of responding agencies reported that they determine slurry seal mixture compositions using the ASTM D 3910 standard, while none of the agencies reported that they use their own design specification for slurry seal mixture compositions. The remaining 67% (2/3) of agencies reported that contractors determine the mixture compositions of slurry seals implemented by their agency (Figure 2-54).

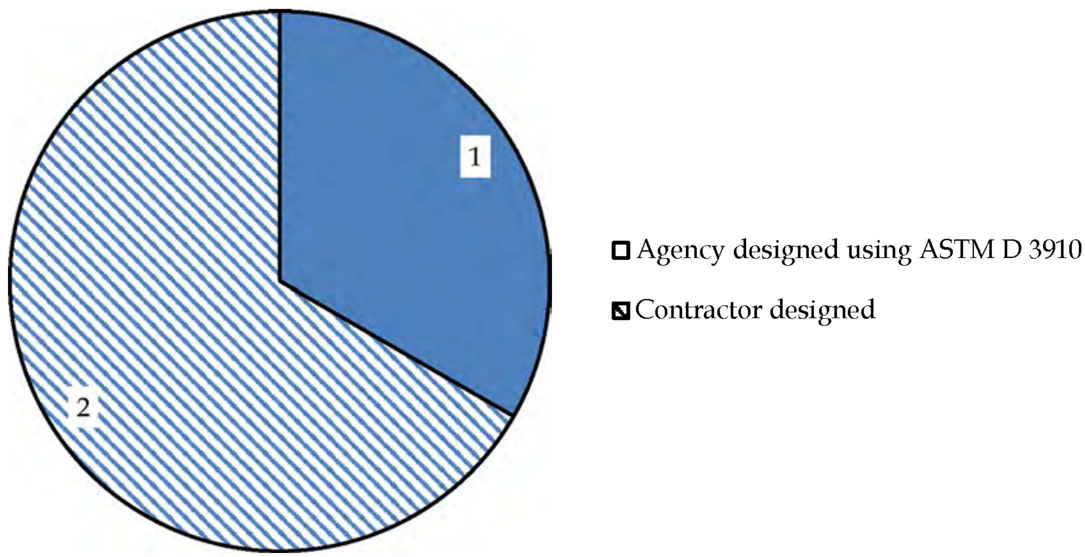

Figure 2-54 Distribution of Responding Agencies with Respect to How They Determine the Mixture Composition of a Slurry Seal (number of responses = 3)

The respondents were also prompted asking how the application rate of the dry aggregate during a slurry seal application is determined. 3/3 respondents reported that their dry aggregate application rate is determined by the contractor. The other options were that the application rate is selected by their agency and is constant for each slurry seal type across all projects, or that the dry aggregate application rate is determined by our agency on a project-by-project basis, or other.

Figure 2-55 shows that 33% (1/3) of the agencies reported that they expect their slurry sealing treatments to have a life expectancy of 4 to 6 years, while the majority (66%, 2/3) of agencies reported that they expect a life expectancy of 7 to 9 years.

Figure 2-55 Distribution of Responding Agencies with Respect to How Long Their Agency Expects a Slurry Seal Treatment Life Expectancy to be (number of responses = 3)

Agencies were polled regarding their most common cause of failures in slurry seal applications implemented by their agency. 33% (1/3) reported that their most common failure cause is due to distresses in the existing pavement, while the other 66% (2/3) reported that their most common failure cause is unknown.

2.6 STATE-OF-THE-PRACTICE RELATED TO MICRO SURFACING APPLICATIONS

Of the agencies that reported implementing micro surfacing treatments on their pavements, 56% (5/9) reported that over the last five years, they have carried-out less than five micro surfacing applications per year as shown in Figure 2-56. 22% (2/9) of the responding agencies reported carrying-out 5 to 10 applications per year, 11% (1/9) carry-out 10 to 20 application, while 11% (1/9) conduct more than 20 micro surfacing applications per year.

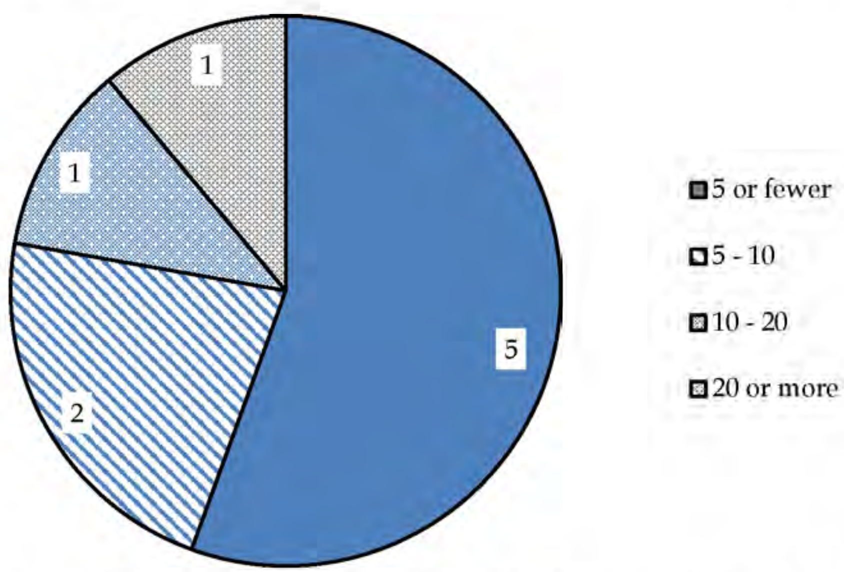

Figure 2-56 Distribution of Responding Agencies and the Number of Micro Surfacing Treatment Applications They have Carried-Out Per Year (over the last 5 years) (number of responses = 9)

As shown in Figure 2-57, the primary distresses that the responding agencies aim to delay or prevent by implementing micro surfacing treatments is fatigue (alligator) cracking, longitudinal cracking, transverse cracking, and loss of skid resistance. Other distresses that the responding agencies reported preventing using micro surfacing were bleeding, raveling, block cracking, and rutting.

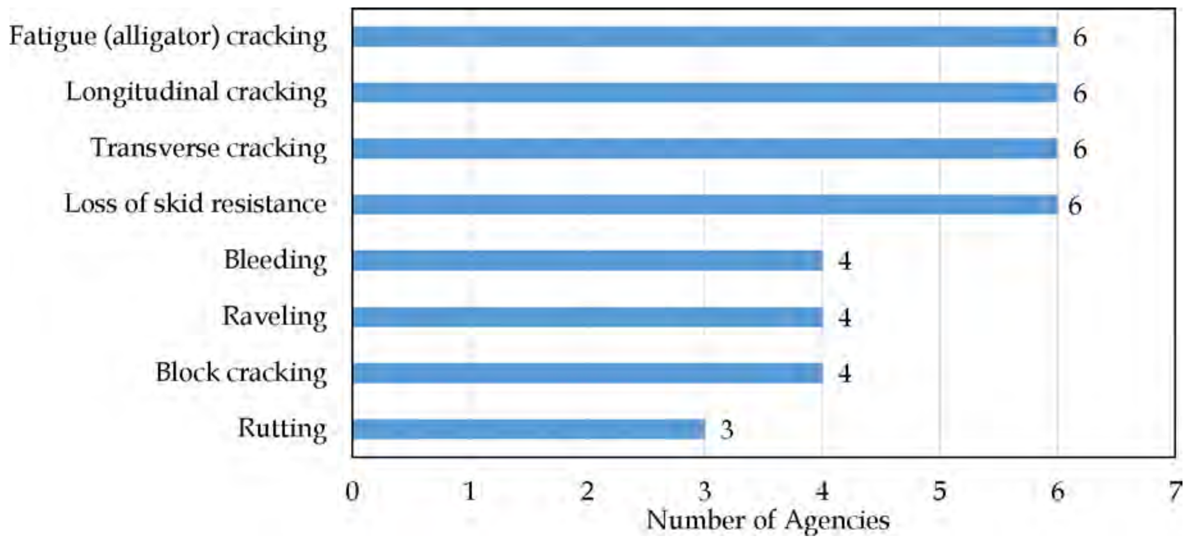

Figure 2-57 Distribution of Responding Agencies and the Distress(es) They Aim to Delay or Prevent by Implementing Micro Surfacing Treatments

Figure 2-58 displays the roadway types (or functional classes) of the pavements that the responding agencies treat with micro surfacing. Per the survey results, micro surfacing treatments are more commonly carried out on rural local roads, urban local roads, and urban minor collectors. They are also reportedly carried out on urban major collectors and rural minor collectors. They are reportedly less frequently carried out on rural interstates and freeways, urban interstates and freeways, rural arterials, rural major collectors, and urban arterials.

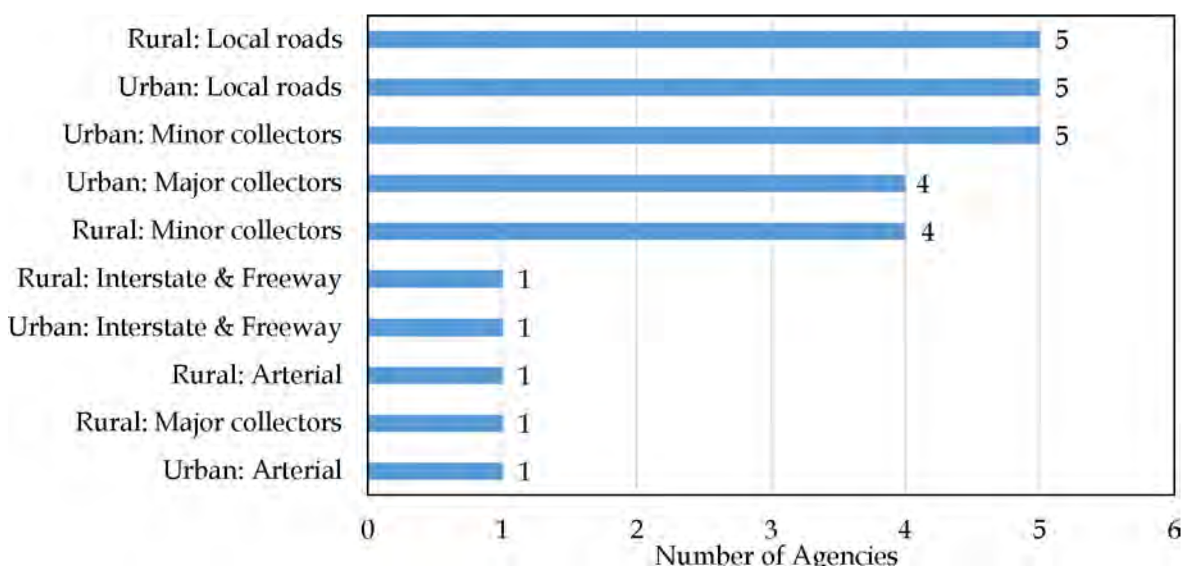

Figure 2-58 Distribution of Responding Agencies and the Roadway Types that They Treat with Micro-Surfacing

As per the PennDOT micro surfacing specification, there are three types of micro surfacing treatments that can be applied to a pavement, and they are as follows:

- Type A: Used to seal cracks, fill voids, and shallow (less than ½ inch) ruts, and provide a scratch course or surface seal
- Type B: Used to fill moderate (½ to 1-¼ inch) ruts; and provide a scratch course, a leveling course, a seal coat, or a surface treatment
- Type Rut Fill (RF): Used to fill deep (2 inch) ruts in a single pass

Error! Reference source not found. Figure 2-59 shows that 67% (6/9) of responding agencies reported that Type A micro surfacing treatment is their most commonly implemented of the three types, while 22% (2/9) of the agencies reported that Type B is their most commonly implemented. Lastly, 11% (1/9) reported that the Type RF is their most common type of micro surfacing treatment that they apply.

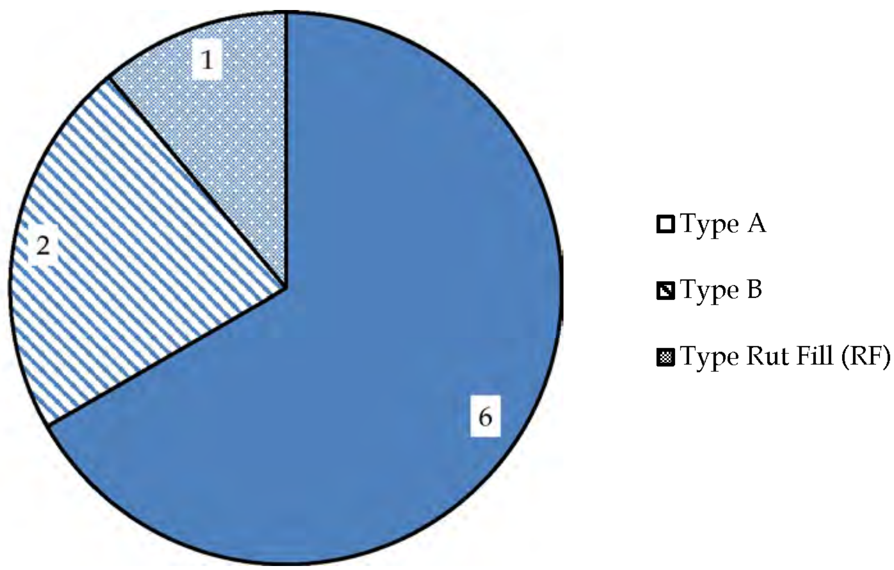

Figure 2-59 Distribution of Responding Agencies Regarding the Most Common Type of Micro Surfacing Application Implemented by their Agency (number of responses = 9)

Per the PennDOT micro surfacing specification, many types of asphalt material are allowable. The responding agencies reported that from that list, they select which of the allowable types to use based on a range of factors as shown in Figure 2-60. Primarily, it was reported that the contractor determines the type of asphalt material. If determined by the agency and not the contractor, the choice of asphalt material is most commonly based on historic use, followed by past performance, project needs (i.e. functional class), and cost.

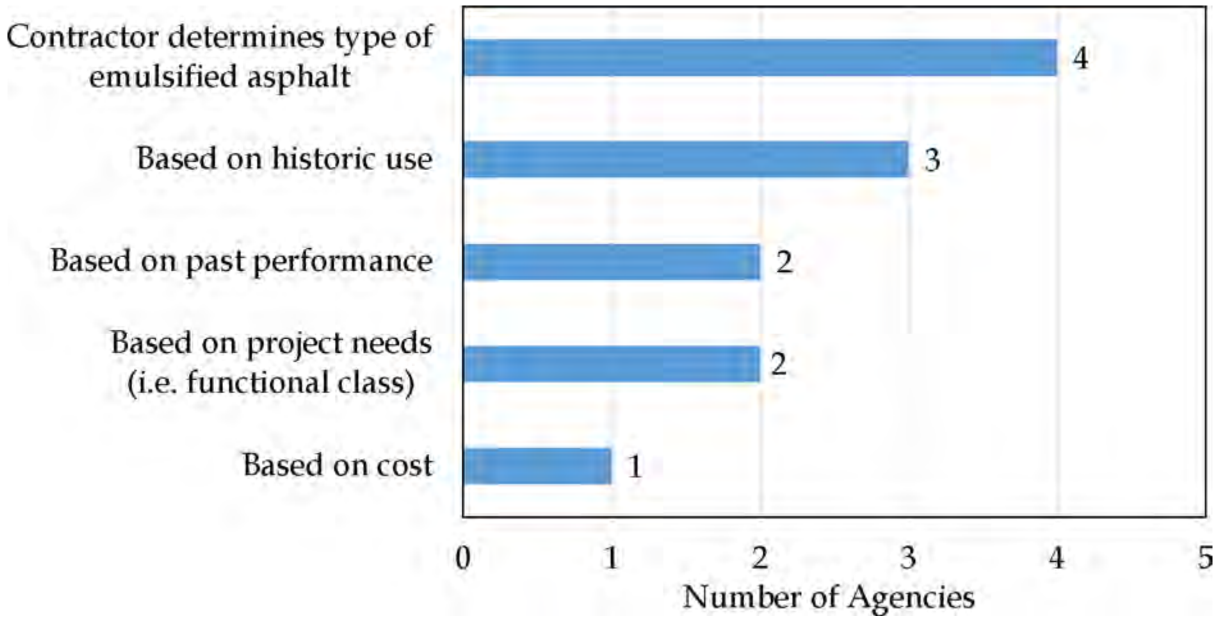

Figure 2-60 Distribution of Responding Agencies Regarding How They Determine Which Type of Emulsified Asphalt Material to Use in a Micro Surfacing Application (number of responses = 9)

In addition to asphalt material, filler material is also an important material to be used in micro surfacing applications. Some agencies reported that the contractor determines the filler type to be used in micro surfacing applications, while other agencies reported that if they determine the filler type, they determine it primarily based on project needs (i.e. roadway functional class), past performance, cost, or historic use (Figure 2-61). Using these factors in their determining methods, agencies reported that they primarily use Portland cement as the filler material in micro surfacing applications, along with limestone dust, as shown in Figure 2-62. None of the responding agencies reported used hydrated lime or fly ash.

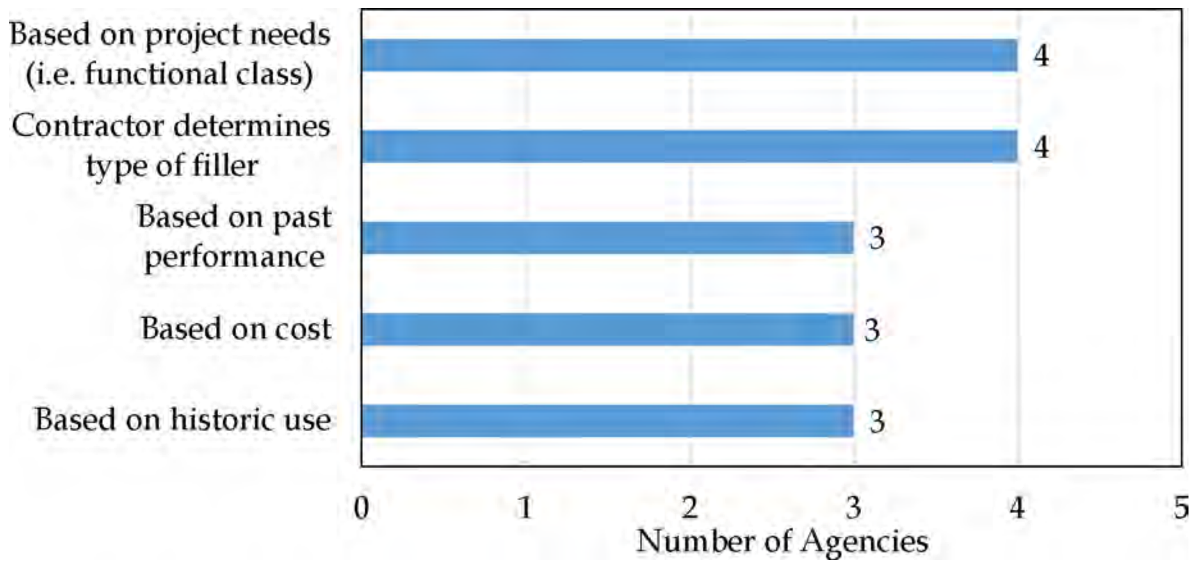

Figure 2-61 Distribution of Responding Agencies Regarding How They Determine Which Type of Filler to Use in a Micro Surfacing Application (number of responses = 9)

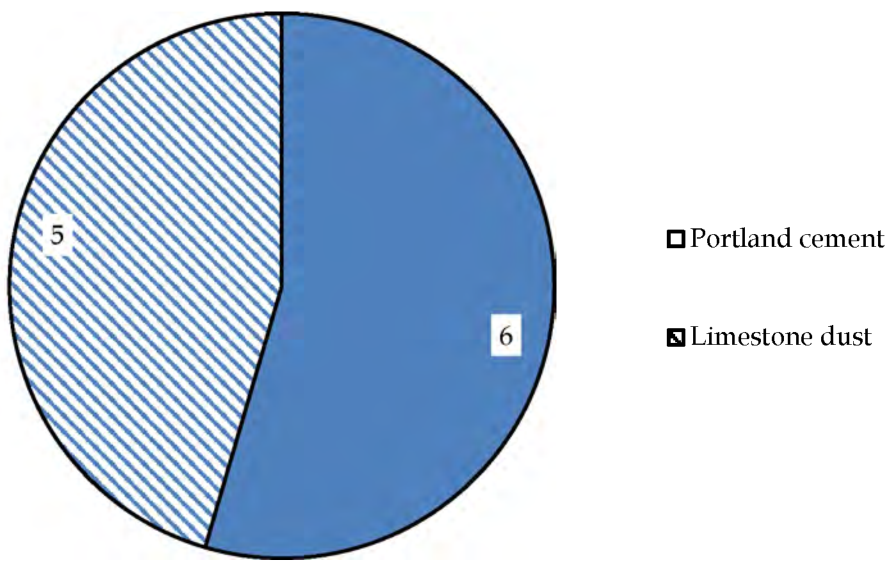

Figure 2-62 Distribution of Responding Agencies Regarding Which Type of Fillers Their Agencies have used in Micro Surfacing Applications in the past 5 years (number of responses = 9)

As shown in Figure 2-63, the mixture composition of micro surfacing applications is reportedly determined in different ways by different agencies. 56% (5/9) of responding agencies reported that they determine micro surfacing mixture compositions using the PennDOT Specification Section 483, while 11% (1/9) of the agencies reported that they use their own design specification for micro surfacing mixture compositions. The remaining 33% (3/9) of agencies reported that contractors determine the mixture compositions of micro surfacing applications implemented by their agency.

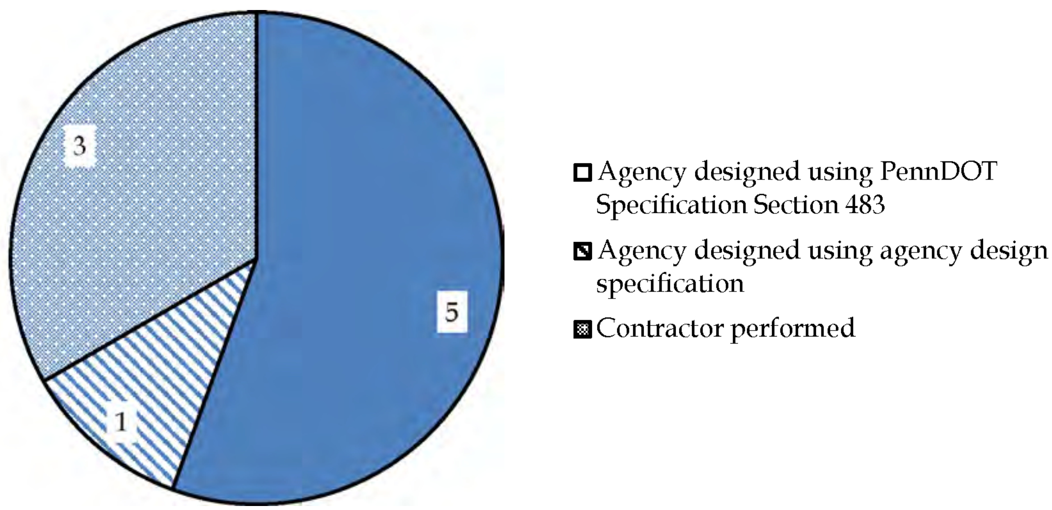

Figure 2-63 Distribution of Responding Agencies Regarding How They Determine the Mixture Composition of a Micro Surfacing Application (number of responses = 9)

As shown in Figure 2-64, the application rate during micro surfacing applications is determined differently by different agencies. 22% (2/9) of responding agencies reported that the micro surfacing application rate is kept constant across all projects performed by their agency, while 33% (3/9) of agencies reported that their agency determines the application rate on a project-by-project basis. The remaining 45% (4/9) reported that their contractors determine the application rate for micro surfacing projects.

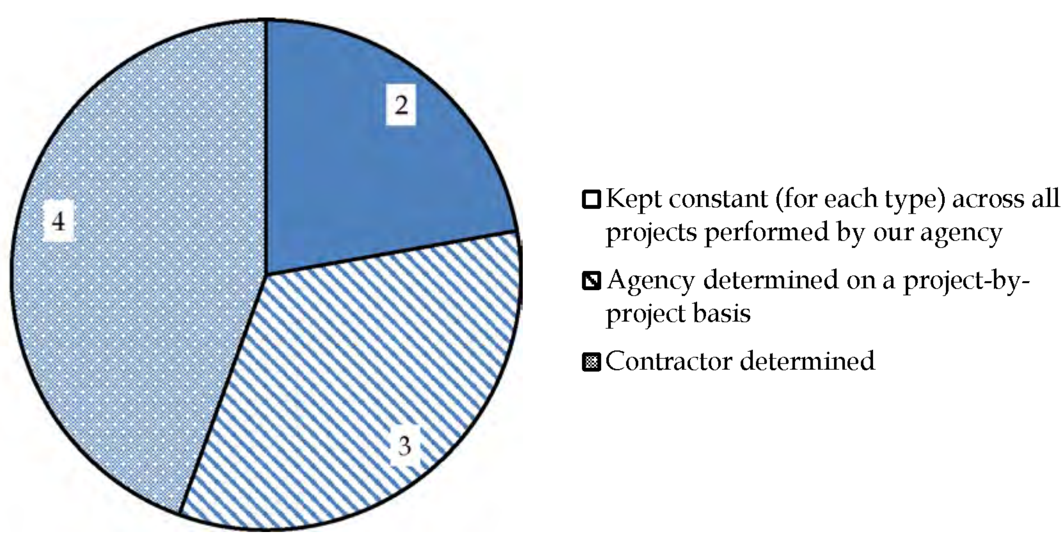

Figure 2-64 Distribution of Responding Agencies Regarding How the Application Rate During Micro Surfacing Applications is Determined (number of responses = 9)

Figure 2-65 shows that 22% (2/9) of responding agencies anticipate the life of a micro-surfacing treatment to be 4 to 6 years, while the majority (67%, 6/9) of responding agencies reported that they expect their micro-surfacing treatments to have a life expectancy of 7 to 9 years. Further, 11% (1/9) of responding agencies reported that their micro surfacing treatments have an anticipated life of 10 or more years.

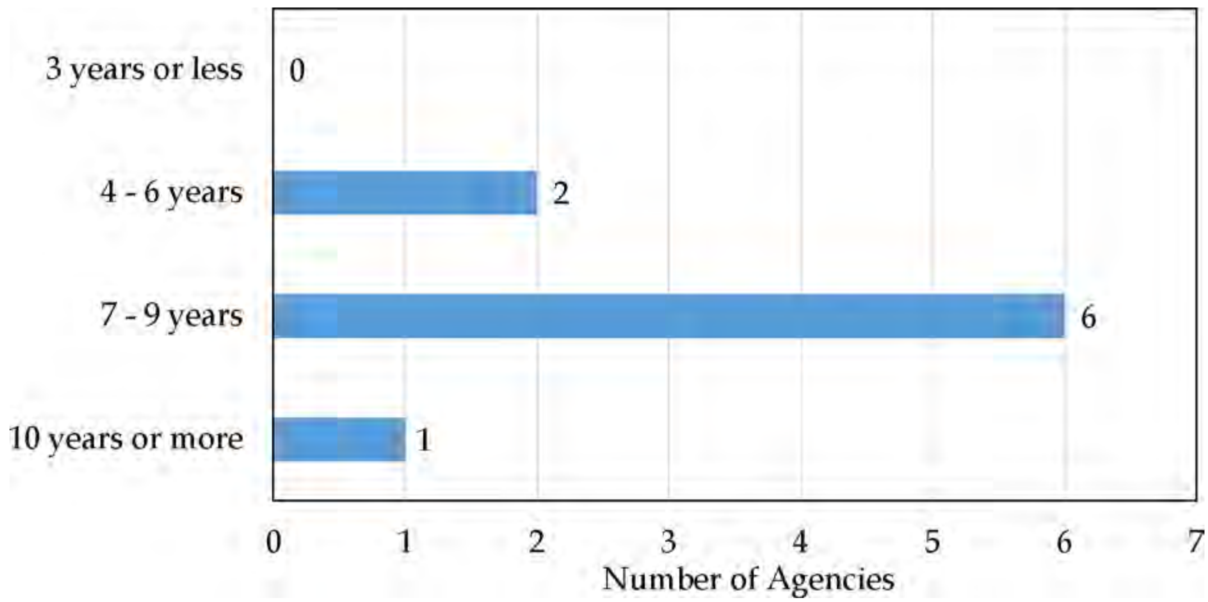

Figure 2-65 Distribution of Responding Agencies Regarding How Long They Predict the Life Expectancy of a Micro Surfacing Application to be (number of responses = 9)

As shown in Figure 2-66, 33% (3/9) reported that their micro surfacing treatments generally do not fail before their expected life. In comparison, 22% (2/9) of the agencies reported that premature failures in their micro surfacing applications are due to distresses in the existing pavement, while another 11% (1/9) reported that their failures are most commonly caused by poor quality of construction during the application of the micro surface. Additional causes of failures reported by the agencies are shown in Table 2-28.

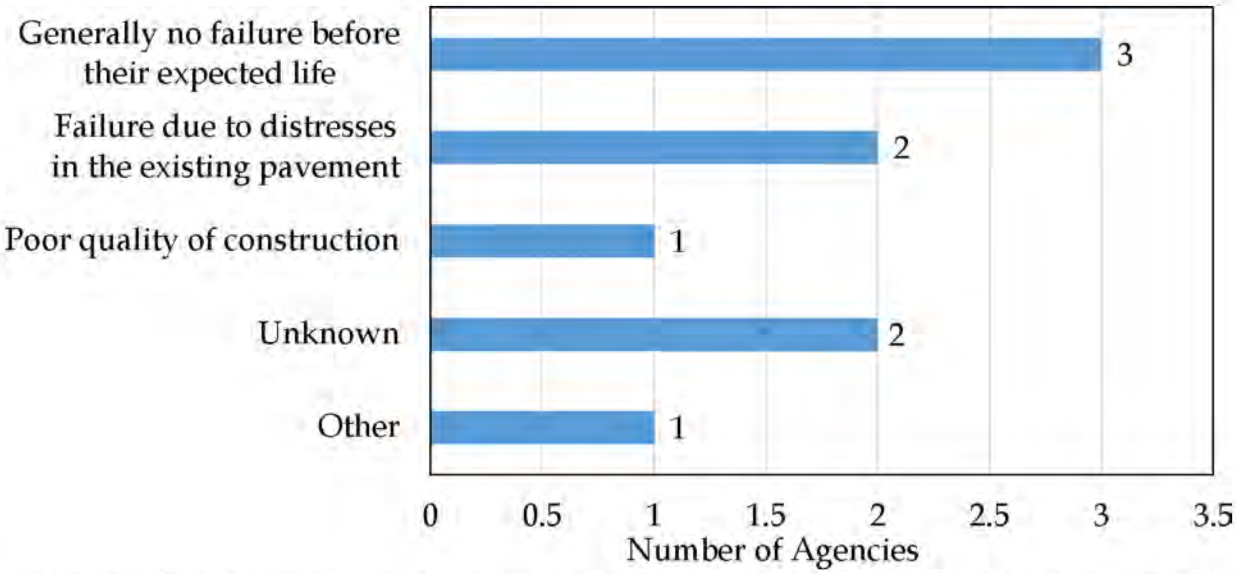

Figure 2-66 Distribution of Responding Agencies and Their Most Common Cause of Failures in Micro Surfacing Applications They Implement (number of responses = 9)

Table 2-28 Agency Reported "Other" Regarding the Most Common Cause of Failures in Micro Surfacing Applications that They Implement

Moisture under the roadway

2.7 STATE-OF-THE-PRACTICE RELATED TO ULTRA-THIN BONDED WEARING COURSES (UTBWC)

Of the agencies that reported implementing UTBWC treatments on their pavements, 56% (5/9) reported that over the last five years, they have carried out less than five UTBWC applications per year, as shown in Figure 2-67. The remaining 44% (4/9) of agencies reported carrying out 5 to 10 UTBWC applications per year.

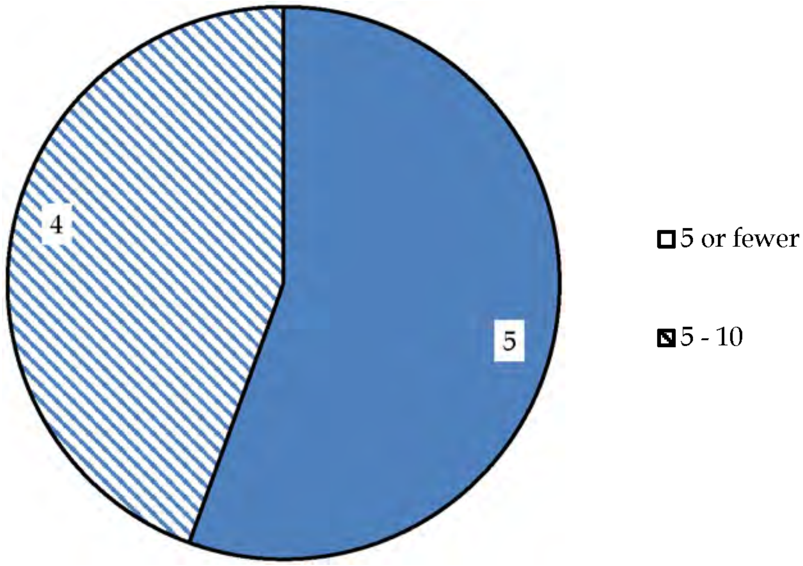

Figure 2-67 Distribution of Responding Agencies with Respect to How Many UTBWC Applications have been Carried Out by Their Agency Per Year (over the last 5 years) (number of responses = 9)

As shown in Figure 2-68, the primary distresses that the responding agencies aim to delay or prevent by implementing UTBWC treatments are fatigue (alligator) cracking, longitudinal cracking, transverse cracking, and block cracking. Other distresses that the responding agencies reported preventing using UTBWC were bleeding and rutting, followed by raveling, followed by a loss of skid resistance on the surface of the pavement.

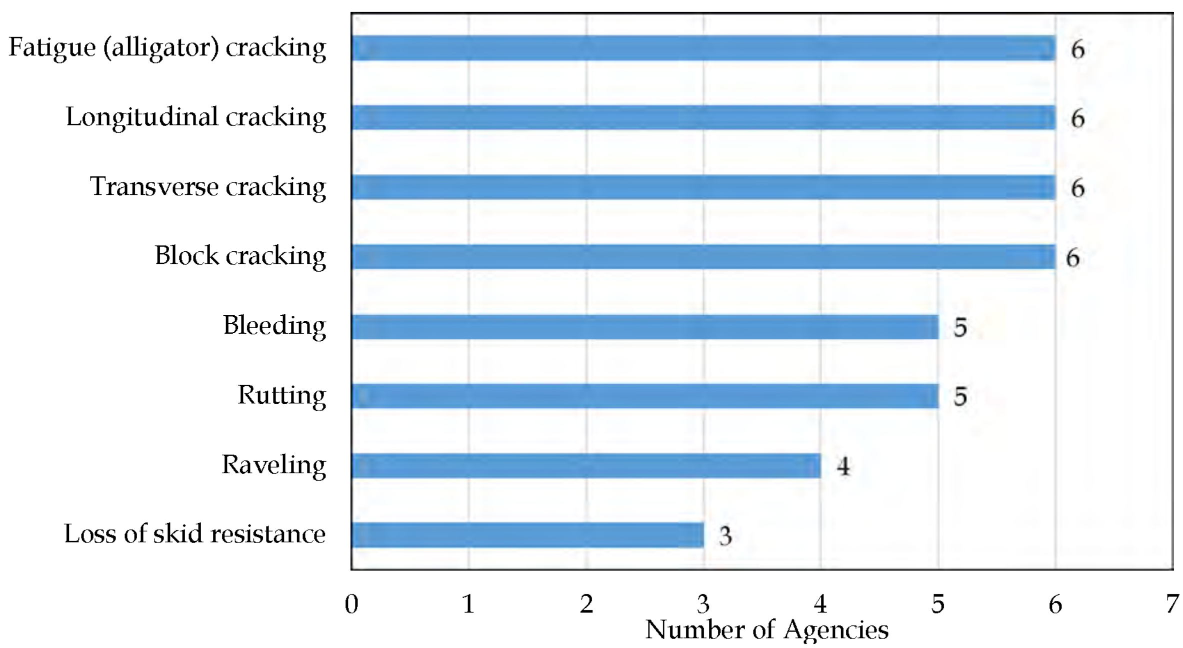

Figure 2-68 Distribution of Responding Agencies and the Distress(es) They Aim to Delay or Prevent by Implementing UTBWCs

Figure 2-69 displays the roadway types (or functional classes) of the pavements that the responding agencies treat with UTBWCs. Per the survey results, UTBWC treatments are most commonly performed on urban local roads, followed by rural local roads and urban major collectors, followed by rural arterials, rural minor collectors, and rural major collectors. Fewer agencies reported that they carry out UTBWC applications on urban minor collectors, urban arterials, or rural and urban interstates and freeways.

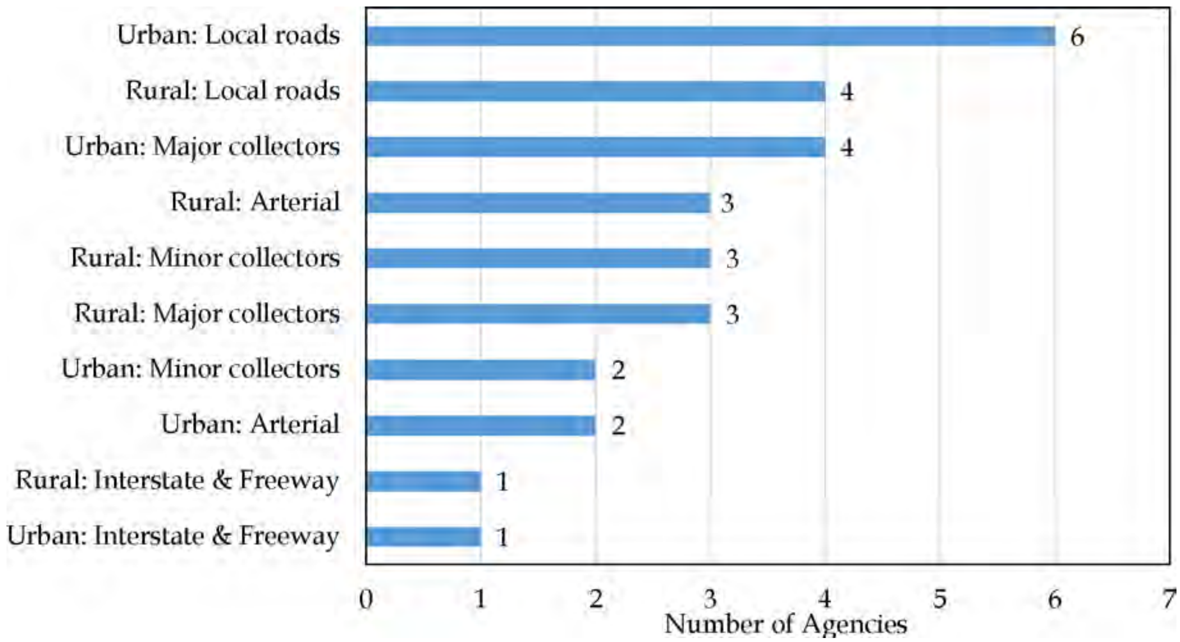

Figure 2-69 Distribution of Responding Agencies and the Roadway Types that They Treat with UTBWCs

Before applying the UTBWC to the pavement surface, agencies apply a tack coat to ensure sufficient tack between the existing pavement and the UTBWC. When applying the tack coat, 100% (9/9) of survey respondents reported that the tack coat application rate is determined by the contractor. None of the responding agencies reported that they determine the tack coat application for their UTBWC applications.

The mixture composition of UTBWC is determined by the contractors for the majority of responding agencies (89%, 8/9), as shown in Figure 2-70. Only 11% (1/9) of responding agencies reported that they determine UTBWC mixture compositions using the PennDOT Specification Section 489, while none of the agencies reported that they use their own agency design specification for UTBWC mixture compositions.

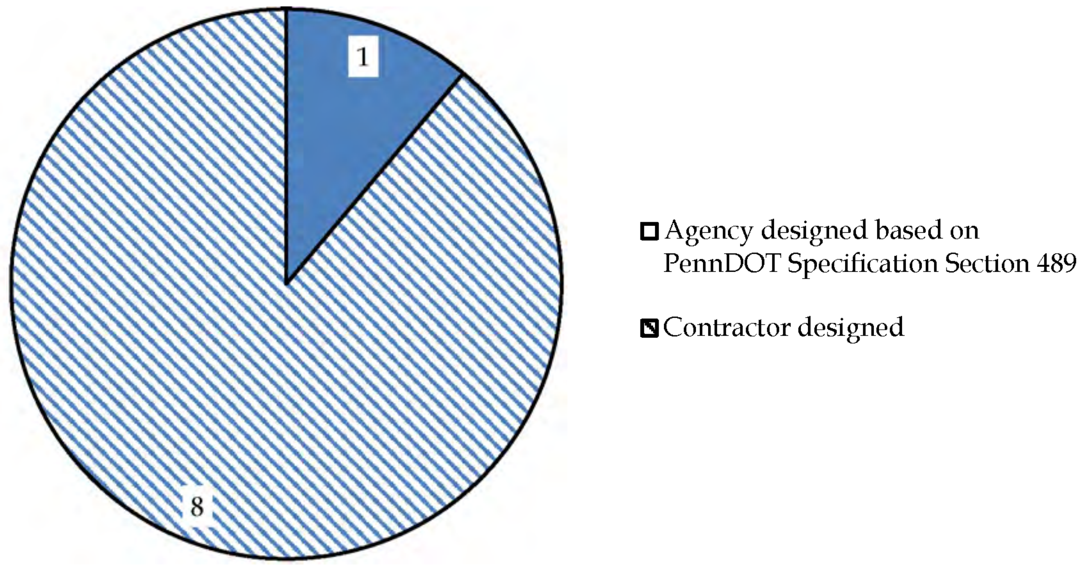

Figure 2-70 Distribution of Responding Agencies Regarding How the Mixture Composition for UTBWC is Determined by their Agency (number of responses = 9)

The typical thicknesses for UTBWCs were reported by the responding agencies and are displayed in Table 2-29. The reported UTBWC typical thicknesses ranged from ¼ inches to 1-½ inches.

Table 2-29 Agency Reported Typical Thickness (or Range of Thicknesses) of UTBWC Applied

¼ inch
¾ inch
¾ - 1-½ inches
< 1 inch
1 inch
1 - 1-¼ inches
1-½ inches

Figure 2-71 shows that 33% (3/9) of the agencies reported that they expect their UTBWC treatments to have a life expectancy of 7 to 9 years, while the majority (66%, 6/9) of agencies reported that they expect a life of at least 10 years for their UTBWC applications.

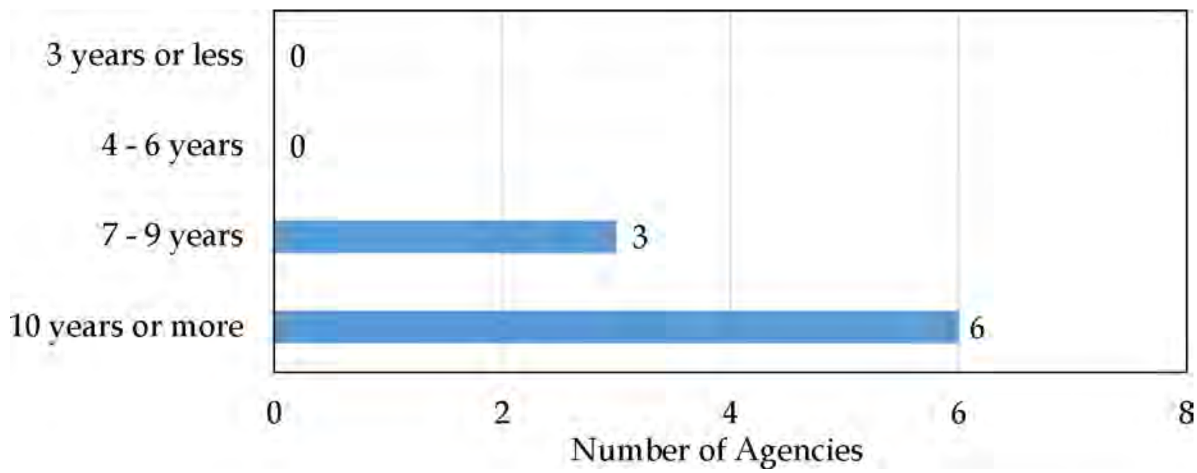

Figure 2-71 Distribution of Responding Agencies with Respect to How Long They Predict the Life Expectancy of an UTBWC Application to be (number of responses = 9)

As shown in Figure 2-72, 44% (4/9) of agencies reported that their UTBWC treatments generally do not fail before their expected life. In comparison, 33% (3/9) of the agencies reported that premature failures in their UTBWC applications are due to distresses in the existing pavement, while another 11% (1/9) reported that their failures are most commonly caused by factors not preventable by the transportation agency, such as weather-related causes, increases in daily traffic, or etc.

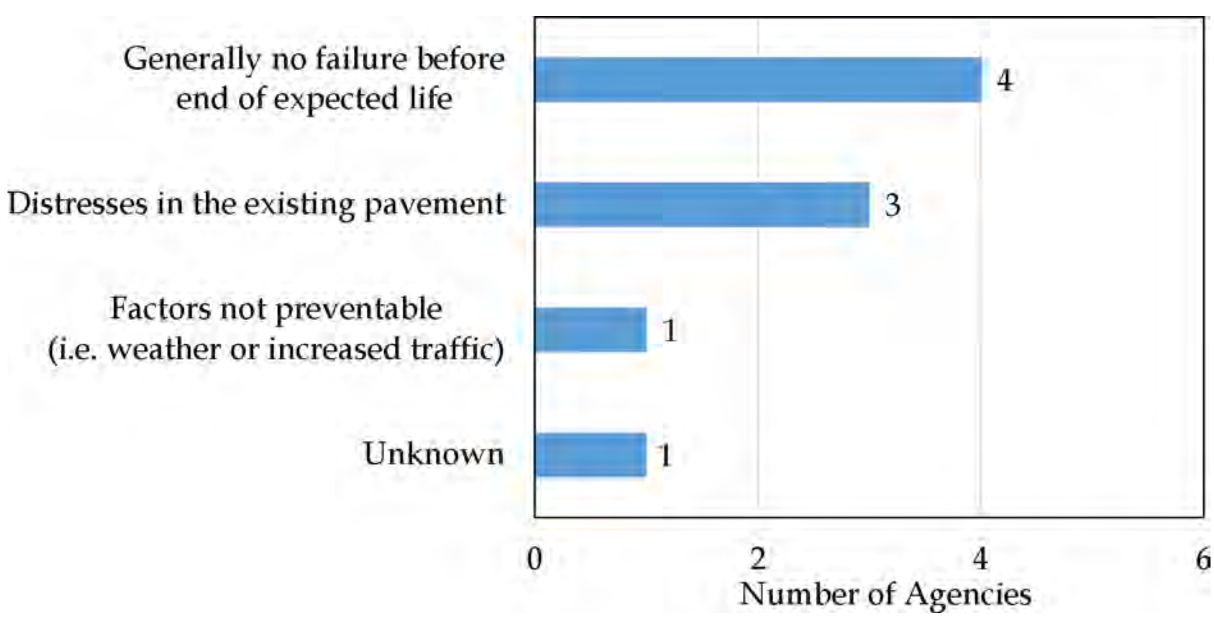

Figure 2-72 Distribution of Responding Agencies Regarding the Most Common Cause of Failures in UTBWC Applications Implemented by Their Agency (number of responses = 9)

2.8 STATE-OF-THE-PRACTICE RELATED TO CONSTRUCTION QUALITY ASSURANCE PRACTICES FOR PAVEMENT PRESERVATION METHODS

Some of the responding agencies reported that the contractors conduct quality control (QC) processes during the construction of pavement preservation treatments. Of these QC practices, as shown in Figure 2-73, the most common parameter evaluated was sampling and testing of emulsified asphalt material, followed by validation of asphalt and aggregate application rates, as well as sampling and testing of the aggregate and other parameters as shown in Table 2-30.

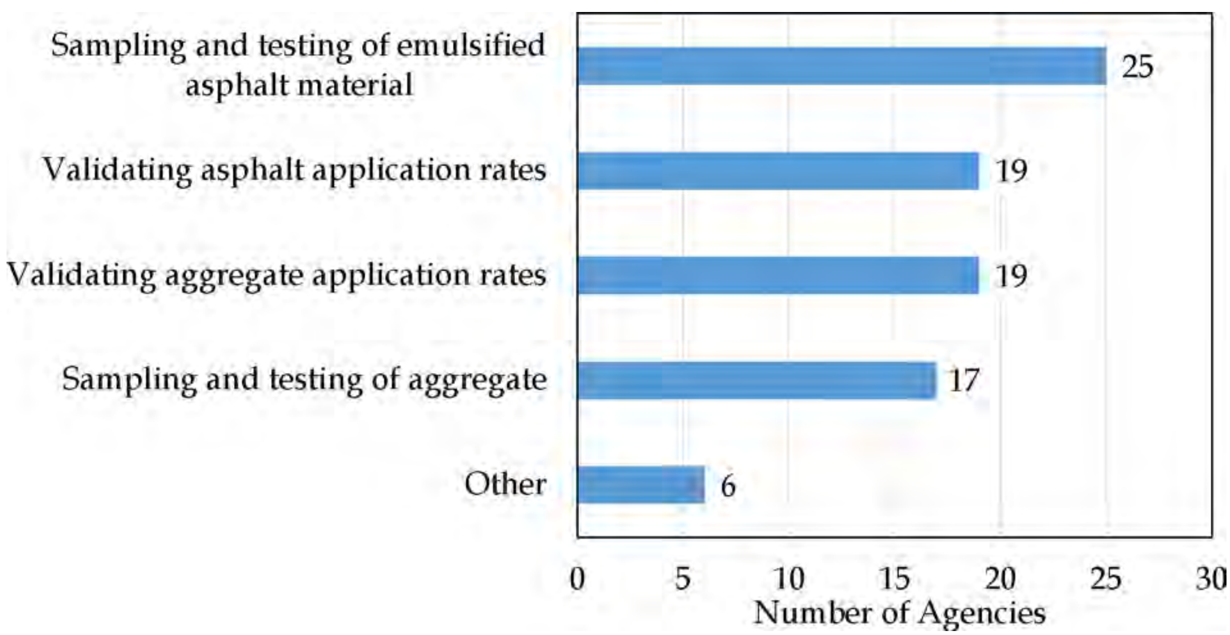

Figure 2-73 Distribution of Responding Agencies Regarding Which Parameters are Evaluated as Part of Contractor QC Process During Construction of Pavement Preservation Treatments (number of responses = 43)

Table 2-30 Agency Reported "Other" with Respect to Parameters Evaluated as Part of Contractor QC Process During Construction of Pavement Preservation Treatments

Unknown
NA
I participate in application process to verify quality
PennDOT
None
All of the above

After pavement preservation treatments are applied, 54% (25/46) of agencies reported that they do not conduct post-construction testing to determine the quality of the applied treatments, while an additional 20% (9/46) reported that they were unsure if their agencies evaluate the quality after application (Figure 2-74). 24% (11/46) of agencies reported that they conduct evaluations of the quality of the applied treatments, 10 of which stated that they do so by visual inspection, and the remaining agency reported that they keep samples of emulsion and aggregate on hand for future testing if they recognize a failure. Another method reported by one agency is displayed in Table 2-31.

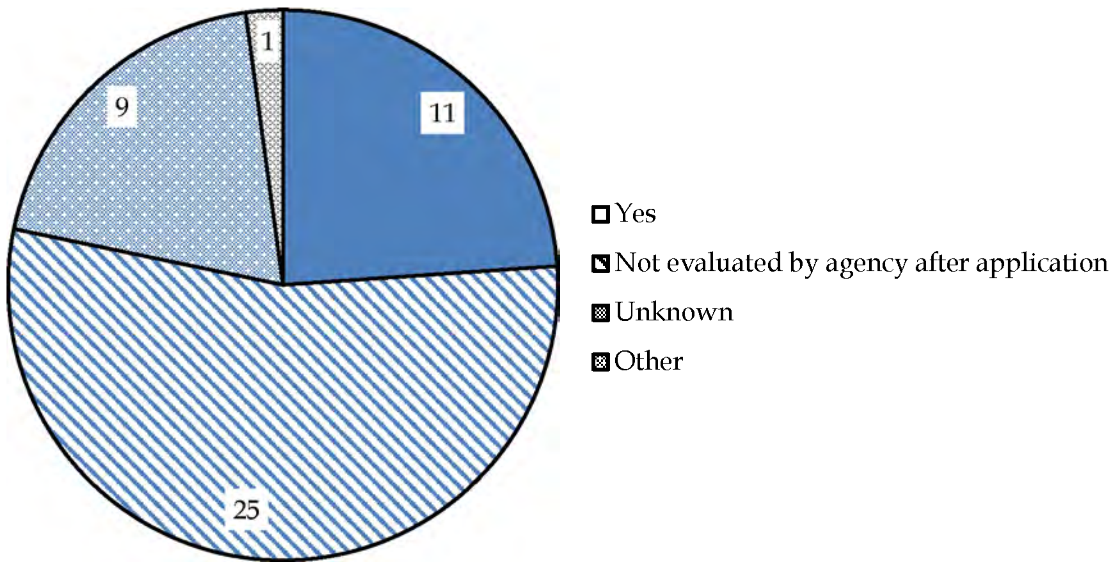

Figure 2-74 Distribution of Responding Agencies Regarding if Post-Construction Testing is Conducted to Determine the Quality of Applied Pavement Preservation Treatments (number of responses = 46)

Table 2-31 Agency Reported "Other" Regarding Whether or Not Their Agency Conducts Post-Construction Testing to Evaluate Preservation Treatment Application Quality

PennDOT Rep evaluates the work

Of the agencies that reported that they carry out pavement preservation treatments, the distribution of if they conduct evaluations of the treatments over time along with the type of evaluations conducted is presented in Figure 2-75. The most common type of evaluation performed is a visual evaluation of distresses over time, followed by an evaluation of the ride quality. 9% (4/47) of agencies reported that they do not conduct performance evaluations to evaluate preservation treatments over time.

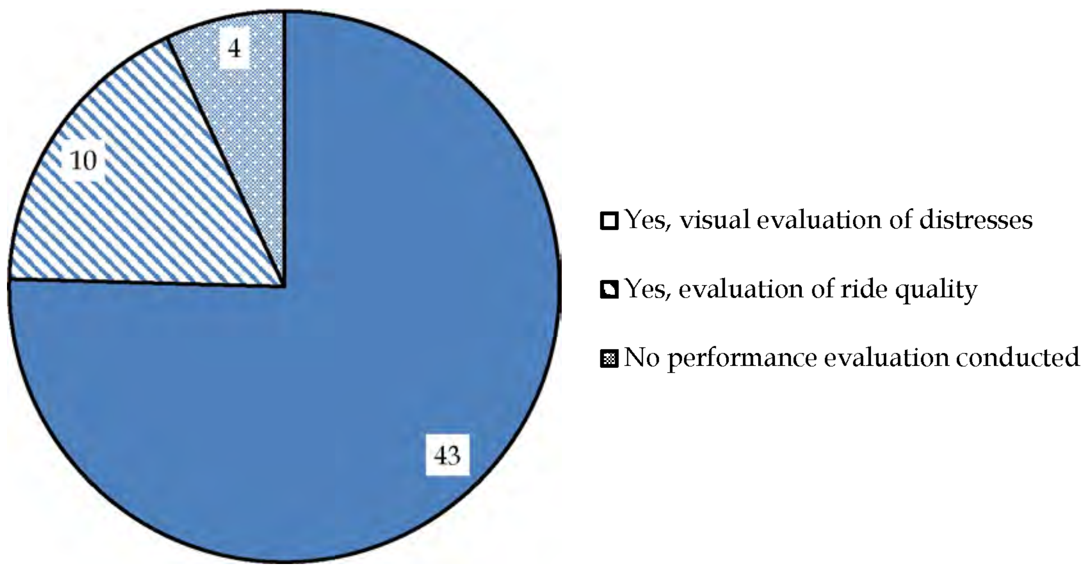

Figure 2-75 Distribution of Responding Agencies Regarding if They Evaluate the Performance of Their Pavement Preservation Treatments Over Time (number of responses = 47)

Only 2% (1/46) of responding agencies reported that they do not employ any treatments to reduce cracking potential in pavement preservation treatments implemented by their agency, as shown in Figure 2-76. The agencies that do employ treatments to reduce the cracking potential reported doing so by patching or crack sealing, or by other methods as reported in Table 2-32.

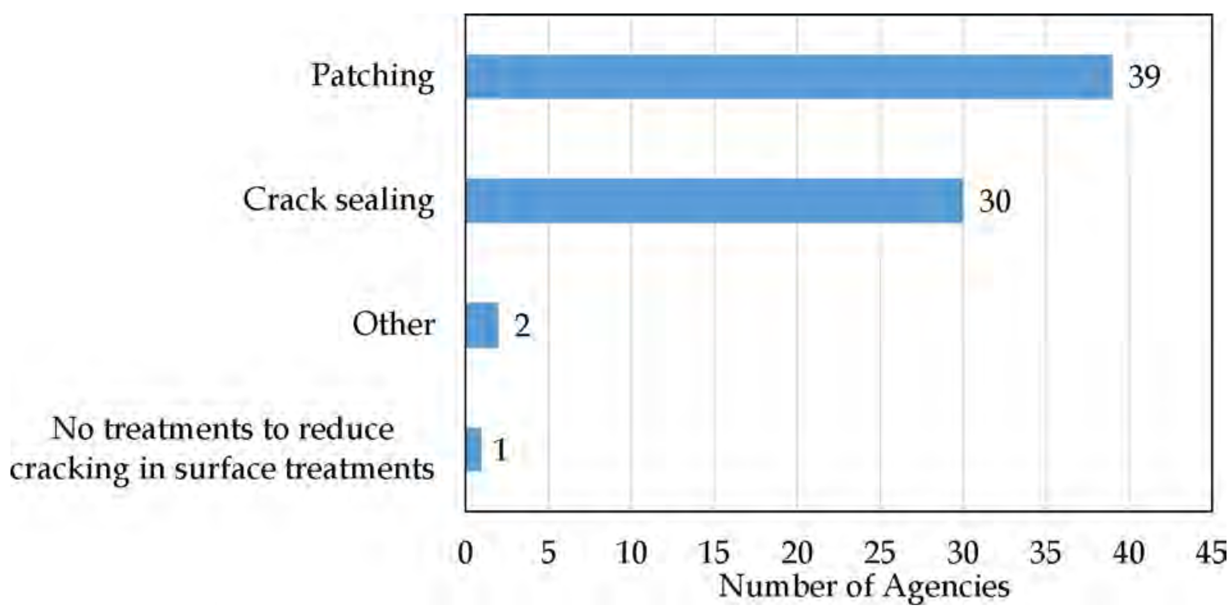

Figure 2-76 Distribution of Responding Agencies Regarding Which Treatments They Routinely Utilize to Reduce the Potential for Cracking in Preservation Treatments (number of responses = 46)

Table 2-32 Agency Reported "Other" Regarding Treatments that are Routinely Utilized to Reduce the Potential for Cracking in Preservation Treatments

Repairs of bad areas and leveling coat of hot mix blacktop

Most agencies (67%, 30/45) responded that they do not quantify the sustainability of pavement preservation treatments or are unsure if this is done by their agencies (Figure 2-77). Agencies that conduct sustainability analysis most commonly use LCA over LCCA approaches. Agencies reporting 'other' indicated that they use PennDOT resources to quantify the sustainability of pavement preservation treatments (Table 2-33).

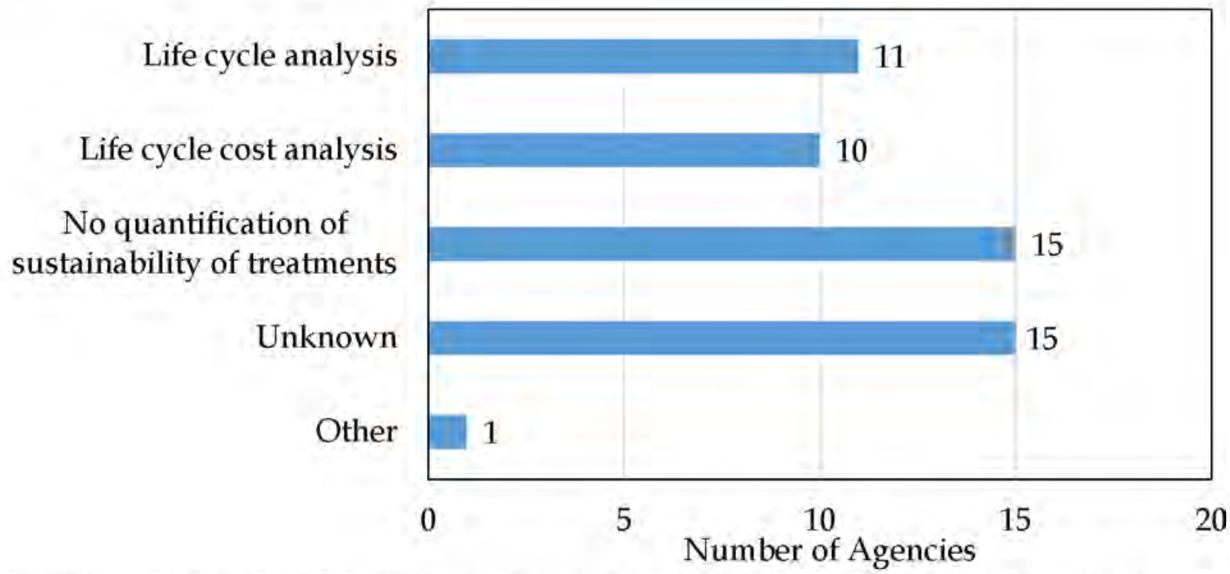

Figure 2-77 Distribution of Responding Agencies with Respect to if they Employ any Efforts to Quantify the Environmental, Economic, or Ecological Impacts (Sustainability) of Implementing Preservation Treatments (number of responses = 45)

Table 2-33 Agency Reported "Other" Regarding if they Employ Efforts to Quantify the Sustainability of Implementing Preservation Treatments

Use PennDOT Rep

2.9 IDENTIFICATION OF KNOWLEDGE GAPS AND FUTURE PLANS

Figure 2-78 shows that 54% (33/61) of respondents reported that their agency has not faced any significant challenges when implementing pavement preservation treatments. The most common challenge (21% 13/61) challenge reported is an overall lack of agency experience. Other commonly reported challenges include a lack of contractor expertise in performing treatments, a lack of mix design methods and engineering-based procedures, and a lack of tests and criteria to determine which treatment to implement. Other reported challenges are shown in Table 2-34.

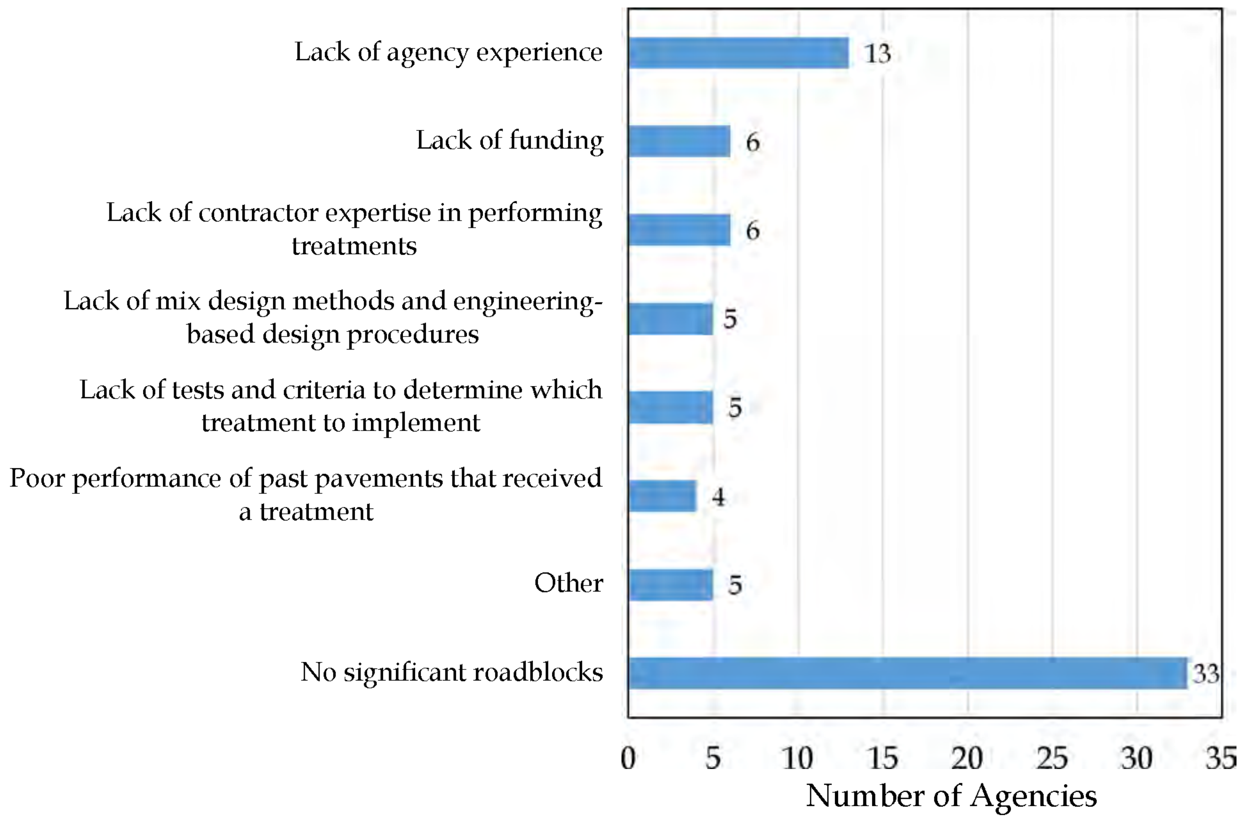

Figure 2-78 Distribution of Responding Agencies Regarding if They have Observed any Gaps in Knowledge or Roadblocks that have Made it Challenging for Them to Start (or Continue) Successfully Implementing Pavement Preservation Treatments (number of responses = 61)

Table 2-34 Agency Reported "Other" Regarding Observed Gaps in Knowledge Making it Challenging to Successfully Implement Pavement Preservation Treatments

Lack of personnel to complete routine maintenance
most of our roads are residential and these treatments tend to cause issues - tracking tar on to driveways - tar on vehicles.-
Focusing on mill/base repair/overlay as a priority for now.
lack of succession planning
We really need to know the life that should be expected based on the structure of the existing road and design accordingly, some roads could go 6 years but others need sealed every 4 to keep water sealed out and not let it get to the subgrade

Despite the above challenges, 55% (34/62) of the responding agencies reported that they have plans to carry out pavement preservation treatments in future projects, while only 21% (13/62) reported that they do not have plans to employ pavement preservation treatments, as shown in Figure 2-79.

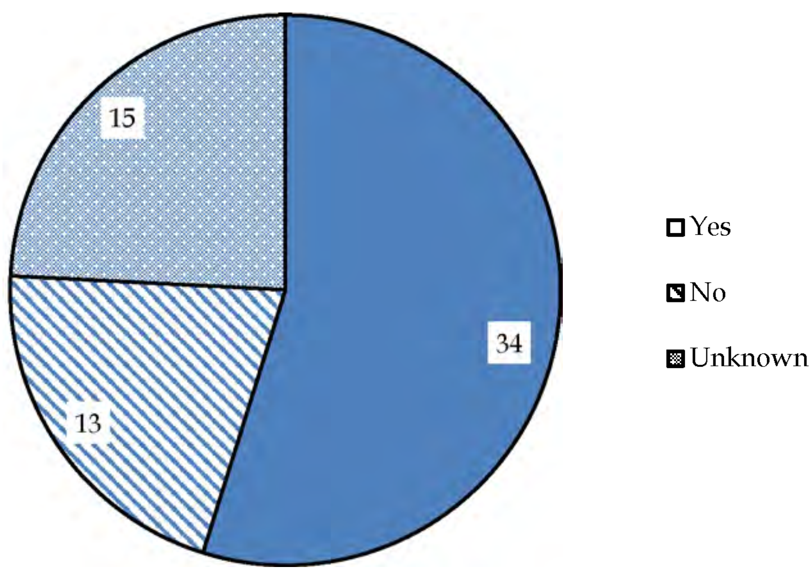

Figure 2-79 Distribution of Responding Agencies Regarding if they Have Plans to Carry Out Pavement Preservation Treatments in Future Projects (number of responses = 62)

Of the agencies that have preservation treatments planned, there was a range of planned treatment types reported. Figure 2-80 shows the number of agencies who reportedly are planning to implement each of the treatment types discussed in this report, while Table 2-35 shows the preservation treatment types planned, along with the number of treatments planned, as reported by each of the responding agencies.

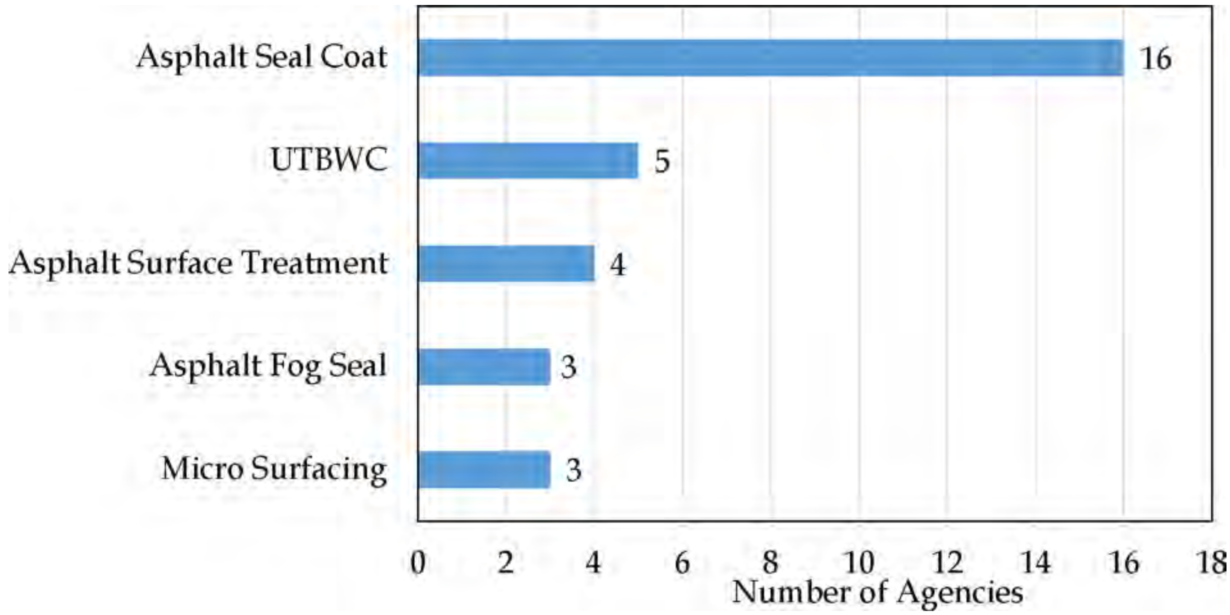

Figure 2-80 Agency Reported Pavement Preservation Treatment Types to be Carried-Out in Future Projects

Table 2-35 Agency Reported Pavement Preservation Treatment Types and Number of Applications Planned to be Carried-Out in Future Projects

This year we will fog seal 2.68 miles on existing HMA roads, and seal coat with flush coat 9.13 miles, that is pretty much annual for us
Multiple applications over the next for years. Asphalt Surface Treatment with fog seal
Annually we constantly physically inspect all roads and seal coats as needed. Slowly treating all gravel roads with Asphalt Surface Treatment. 3 seal coats for this year. 3 Seal Coats and 1 Surface Treatment for next year.
ongoing road maintenance
Crack Sealing - every road every 3-5 years, Patching - every roadway as needed, Mechanical patching - every 6 years on low-level roadways, Seal coat every 6 years on low level roadways
seal coat
seal coat-1 paving-1
continue what we have been currently doing
Crack sealing and seal coating
FDR and multiple seal coat layers
we do selected roads on a rotational basis when funding available
treatments will be part of a regular roadway management program.
Cape sealing

Chip Sealing and Micro Sealing
Future UTBWC
2025&2026 UTBWC
All aprons and new paving
we will continue to implement crack sealing and seal coating on a yearly basis.
seal coat
tar and chip, new top coat paving
Reviewing options for surface treatments in newer neighborhoods less than 15 years old with roadways of proper engineering design.
Ltap is working with us to plan ahead
Single seal with a fog seal(
We are placing 123,500 square yards of Double Application Seal Coat this year.
Double coat chip seal and Ultra-thin Bonded wearing course
Chip seal, micro rut fill and ultra thin wearing course
our annual maintenance projects will include crack sealing, and continued use of microsurfacing and or UTBWC. We are considering use of chip sealing on low volume alleys.
Asphalt Rejuvenator
All 85 miles of Township roads, on a 5 year cycle
Seal Coat Treatments, many performed yearly.
PennDOT Allegheny County Maintenance completes preservation treatments on approximately 40-50 roads per year.
We have been performing large scale mill and fill patching to prep roads in hopes of correcting deficiencies and add life to seal coats, we are also trying to add structure to roads that have never been paved in hopes of prolonging the life of seal coats

Table 2-36 states additional information and thoughts that were reported during the survey regarding pavement preservation treatments from the responding agencies.

Table 2-36 Agency Reported Additional Information and Thoughts Regarding Pavement Preservation Treatments

We only have about 150' of pavement in the township. We only use anti-skid during winter, and maintain the dirt/gravel roads as necessary.
We view fog seals, seal coats, and flush coats (fog on top of seal coat) as extremely valuable maintenance tools to allow us to preserve our roads at the lowest annualized cost to taxpayers. I'm always happy to talk if you have questions.
If the road has a good sub-base, base and is structurally sound, seal coat is all that is needed. No need to build up shoulders. Asphalt Surface Treatment prevents loss of

aggregate and provides for a smooth ride. Some residents complain about Seal Coating, but we find that it is very cost effective and especially helpful for traction on the hills and curves. Periodically when we do pave, a road those same people complain that traffic drives to fast.
Lack of funding for County and local municipalities is a huge roadblock when it comes to pavement preservation treatments. The budgets of these entities are extremely small especially for the rural areas. There needs to be a better effort to distribute the funding equally to the rural areas of the State and not just the urban areas. These municipalities don't have huge populations but they do have huge road and bridge networks that they need to maintain, not only with paving but also winter maintenance. Also, these same municipalities may only have 1 or 2 road crew members due to budget restraints.
If you need further information you would probably want to talk to the roadmaster, Colin Reynolds, he probably has a little more knowledge on this than I do, I don't go to the project like he does. Thank you
Our process begins with FDR and 3 layers of seal coat. The first layer with larger stone. Limited access to Penn Dot certified slag requires us to use limestone that is soft and "polishes" quickly leaving the surface slick in rain and snow.
most of our roads are residential and these treatments tend to cause issues - tracking tar on to driveways - tar on vehicles. Treatments are better suited for non-residential streets.
Everyone here has less than a year's experience except myself. I have been the Administrator for 13 years and am now a roadmaster as well and expected to head everything up with little road experience. In other words, we are flying by the seat of our pants right now!
We Just started UTBWC in 2022 and it is working very well for us.
none
our contractors always complain that the PennDOT rule book forces them to use junk materials.
I am excited to see the outcome of the 1/4 in chip seal. I have talked to a lot of other Townships about it and they are very happy how it turns out. We tried it for the first time in our park. We did a 1/2 chip seal first with 1/4 in chip seal over top. So far i am very impressed how it has done.
Carlisle places high value on pavement preservation. We are expanding our road condition analysis efforts in order to more effectively plan our roadwork projects and to get the most efficient use of our road maintenance funding. We emphasize trying

to prevent roads from reaching a condition which requires more extensive and more expensive treatment methods.
We have an extensive paving budget. Paving is completed by the public works department. We have a rating system where each road in the township is rated A-D. We have a 10–12-year paving cycle for each township road. We also repair any problems that arise during that period.
A contractor used slag last year, as it was allowed by PennDOT specs. DO NOT USE! Terrible. A year later, the roads are producing as much dust as the day after the treatment was laid. We added "NO SLAG" to our bidding specifications, and HIGHLY recommend the same for other municipalities.
We do an excellent job at providing quality seal coat operations, but PennDOT is trying to get the maximum life out of these treatments, so we really need a guide that would allow us to form an educated determination of how long a seal coat should last, based on the age and structure of the existing asphalt course that is being preserved. This would help us to determine which treatment would be best and what that life expectancy is accordingly. I do not believe it is not the quality of the treatment that is failing, it is the structural integrity of the surface we are placing it on.

2.10 SURVEY KEY FINDINGS AND SUMMARY

This section details the findings from the survey that was administered as part of the IRISE study, Asphalt Pavement Seal Coats: Best Practices and Experience. The survey collected information from numerous Pennsylvania municipalities, counties, and PennDOT representatives. 75% of responding transportation entities reported that they implement pavement preservation treatments on their roadways. From these agencies, it was reported that the most commonly implemented treatment is the asphalt seal coat, followed by the asphalt surface treatment. Asphalt fog seals, micro surfacing, UTBWCs, and slurry seals were also reported to be used by some of the responding PA entities. With that, 78% of the responding agencies reported that contractors carry out all the preservation treatments on their roadways while their agencies do not.

Regarding asphalt seal coats, agencies reported most commonly implementing this treatment type on rural, local roads, to primarily delay or prevent fatigue, longitudinal, transverse, and block cracking. When applying an asphalt seal coat to their roadways, the majority of agencies reported that the determination of application rates of the asphalt and aggregate, along with the mix design are conducted by the contractor. Further, responding agencies reported that determining the type of emulsified asphalt materials to be used in a seal coating application is most commonly based on the past performance of the different emulsified asphalt types available. As for the aggregate material, the majority of agencies reported that they use washed, virgin aggregate in their seal coats, while some agencies also reported conducting these treatments using recycled asphalt pavement, or precoated aggregate, noting that the decision to use precoated aggregate was reported to be primarily based on the properties of the aggregate being used. After a seal coating application, 78% of responding agencies reported that they immediately permit traffic on the treated surface to travel as usual at normal speeds. After the construction of a seal coat, only 11% of responding agencies reported that they perform post-construction testing to determine the percent embedment of the aggregate in the asphalt, which was reported to be primarily conducted by visual evaluation. 75% of responding agencies reported that they do not evaluate the percent embedment after construction has been completed. To conclude, the majority of agencies reported that their asphalt seal coating treatments have an expected life of four to six years, while the most common cause of failure in these treatments that they experience is due to distresses that were present in the existing pavement.

Fog sealing is a different pavement preservation treatment that was reported to be carried out less frequently than seal coating treatments, but also sometimes in conjunction with seal coating treatments. 58% of responding agencies reported that they only perform fog seals on top of seal coats and not as independent treatments. Because of that, similar to seal coats, agencies reported that they primarily apply fog seals to rural local roads. In addition, 58% of responding agencies reported that they never apply fine aggregate with the asphalt material in fog sealing applications, while 17% reported that they always apply fine aggregate with the asphalt material. The remaining 25% of agencies that they do sometimes, depending on different factors for each application. Most agencies concluded that they expect their fog seal applications to last four to six years.

As described in the beginning sections of this report, an asphalt surface treatment is essentially a double seal coat application. After seal coating applications, this was the second most commonly implemented preservation treatment by the responding agencies. They reported that the primary distress that they aim to delay or prevent by applying asphalt surface treatments is fatigue cracking, followed by transverse and longitudinal cracking, and primarily this is conducted on rural local roads. Further, agencies reported that the primary factor considered when deciding whether to apply an asphalt seal coat or an asphalt surface treatment is the existing condition of the roadway, or the existing distresses present in the pavement structure. The majority of agencies further reported that they use washed, virgin aggregate in these applications. After an asphalt surface treatment application, 65% of the agencies reported that they immediately permit traffic to drive on the pavement. Further, the majority of agencies (57%) reported that they expect their asphalt surface treatment applications to have an expected life of approximately four to six years.

Slurry seals were reported to be the least commonly applied treatment type by the responding agencies. Of the agencies that did report conducting slurry seal treatments, they were reported to be most commonly used to delay or prevent transverse cracking, and primarily on rural or urban local roads, with the majority of agencies reporting an expected life of the treatment to be approximately seven to nine years.

Micro-surfacing is another treatment that is reportedly used to preserve pavements by these Pennsylvania transportation entities. Micro-surfacing treatments are reportedly most commonly used to delay and prevent fatigue, longitudinal, and transverse cracking, along with improving skid resistance on a roadway. This type of treatment was reported to be carried out most commonly on rural and urban local roads, and minor collectors, along with urban major collectors. These are most commonly the Type A micro surfacing treatments used to seal cracks and to fill voids and sallow ruts. Micro-surfacing treatments most commonly were reported to have a life expectancy of approximately seven to nine years.

The last preservation treatment discussed in this study is UTBWCs. According to the reporting agencies, when they carry out UTBWC treatments, it is most commonly to delay or prevent fatigue, longitudinal, transverse, and block cracking, and most commonly carried out on urban local roads, followed by rural local roads and major collectors. 89% of responding agencies also reported that the mixture composition for UTBWC treatments is contractor-designed, as opposed to being designed by their agencies. Further, the reported UTBWC typical thicknesses ranged from ¼ inches to 1-½ inches, with the average being approximately a 1-inch thickness. The reporting agencies further reported that these treatments generally have a life expectancy of ten or more years.

After the application of these above discussed pavement preservation treatments, it was reported by 93% of responding agencies that they evaluate the performance of the treatments over time by visual evaluation of distresses. In addition, 54% of responding agencies reported that their agency has not faced any significant challenges when implementing pavement preservation treatments. The remaining agencies reported the most common challenge being due to a lack of agency experience, lack of funding, or lack of contractor expertise in performing treatments. Despite these challenges being experienced, 55% of responding agencies reported that they have plans to carry out pavement preservation treatments in future projects.

SECTION 3: INTERVIEWS OF PENNSYLVANIA TRANSPORTATION ENTITIES

The next step in this project is to select agencies along with their contractors who completed this survey to interview. These interviews will be used as case examples to gain further insight on best practices for pavement preservation treatments by gaining further knowledge on what has and what has not, worked for Pennsylvania transportation entities when applying preservation treatments to their roadways.

Interviews were conducted with 6 different transportation agencies in Pennsylvania. Two PennDOT representatives from different districts were interviewed, one PA turnpike commission representative was interviewed, and three representatives from different PA municipalities were interviewed. The summary and findings of each of these interviews are reported in this section.

3.1 AGENCY INTERVIEWS

Interviews were conducted with representatives from PennDOT District 9, PennDOT District 10, the Pennsylvania Turnpike Commission, Big Beaver Borough, Cranberry Township, and Potter Township. The summaries of each of these interviews are reported in the following sections.

3.1.1 PennDOT District 9

State-of-the-Practice Related to the Use of Pavement Preservation Treatments

PennDOT District 9 carries out asphalt seal coats, asphalt fog seals, and asphalt surface treatments as their pavement preservation practices. Some of these treatments are performed by contractors, while others are performed by their agency crews. As a district, they prefer to do most of their seal coats internally. With that, the only time they contract out the work is when there is a shortage of laborers for the current projects taking place or if another larger project is ongoing concurrently. That said, the majority of PennDOT District 9's preservation treatments are done in-house.

When implementing pavement preservation treatments, the agency always follows a checklist process primarily aimed at quality control. Their seal coating treatments are scheduled as cyclic maintenance and are performed every 6 years. In addition, 3 years in advance of a seal coating application, larger issues in the pavement structures are evaluated (such as water mains are fixed). Then, 1 year prior to a seal coating application, District 9 conducts mill and fills, base repairs, crack sealing, and patching as needed. District 9 has used PennDOT Publication 242 as the guidance for their pavement preservation practices.

PennDOT District 9 predominantly uses asphalt seal coats to correct cracks that are ¼-inch or smaller and to seal the surface of the pavement to avoid freeze-thaw damage potential. District 9 has also applied some asphalt surface treatments (double seal coats), where they use aggregate number 67 as the first layer, and number 8 as the second layer. They have used the asphalt surface treatments more as a low-cost maintenance treatment, and not as preservation. They have found that their asphalt surface treatments perform almost as well as a 1-inch overlay does. PennDOT District 9 has also experimented with applying thin lifts during construction but not as maintenance or preservation treatments. However, they have encountered some issues with their thin lifts due to shoving.

State-of-the-Practice Related to Asphalt Seal Coat Treatments (also commonly known as "chip seals")

Based on past performances of other emulsified asphalt types, PennDOT District 9 uses only CRS-2PM emulsion in their asphalt seal coats. They also conduct compatibility test with aggregate suppliers to see if RS-2PM is needed. As for the aggregate material used in seal coating operations, District 9 uses primarily washed, virgin aggregate. They have also experimented with using RAP as the aggregate material in seal coats as well. They found that on most roadways, they had no issues with using RAP compared to when they used washed aggregate. On some roadways with higher ADTs, they did encounter some flushing and bleeding issues when using RAP, but on most of the roadways, they did not experience any issues. They also reported that using RAP in seal coating operations costs them about one third of the cost of using virgin aggregate. One other issue that they encountered was that when using the RAP, during the construction process, the chip spreader needed to be periodically cleaned to ensure that the aged asphalt material was not sticking to the inside of the equipment.

After the construction of a seal coat, District 9 permits traffic to travel as usual at normal speeds on the same day. They like to ensure that when applying a seal coat, the air temperature is at least 60degF and rising, with rain not forecasted. This allows for proper, fast curing of the seal coat, permitting traffic to travel over the roadway within the same day. District 9 generally performs its asphalt seal coating treatments over 6-year cycles. However, some counties in their district have not had funding to maintain the 6-year cycle, and thus they have extended the number of years between each treatment, while other roads in other counties are well past their useful life and thus are being treated with seal coats more frequently to try to maintain the condition and extend the life of the pavement as far as possible.

Overall, District 9 reported that the most common cause of failures in their asphalt seal coating applications is due to improper timing for an application such as an application late in the season under cooler temperature conditions, or an application on a roadway that had dampness on the roadway during placement preventing proper adhesion of the treatment to the existing surface. District 9 reported that they have not experienced many failures due to the construction itself. They reported that one main reason for this is that they hold a 'Calibration Day' once every construction season. On these days, the crew all get together to share knowledge and experience with each other to ensure that best practices are being upheld by all members of the crew. In addition, all the equipment is there on these days to ensure that it is all working as it is supposed to.

State-of-the-Practice Related to Asphalt Fog Seal Treatments

District 9 reported that they have sometimes applied asphalt fog seals on top of asphalt seal coats. They have only conducted this as experimental trials, and do not do so often. They tested it out on roadways with higher ADTs and applied the fog seal one day after the seal coat was applied. In their experience, these applications have primarily impacted the aesthetics of the roadway, and not the structure of the pavement or the performance of the seal coat.

State-of-the-Practice Related to Asphalt Surface Treatments (also commonly known as "double chip seals")

District 9 reported that they primarily conduct asphalt surface treatments as opposed to asphalt seal coats on roadways with higher ADTs (greater than 1000) to add additional structure to the pavement. When constructing these treatments, District 9 applies the first coat and second coat back-to-back with little to no time in between. This is because the first course of aggregate is coarser, therefore providing a very rough surface for traffic to travel on. As with the asphalt seal coat treatments conducted by District 9, they reported that the most common causes of premature failures in asphalt surface treatments are due to constructing outside of the appropriate season, preventing proper curing of the treatment.

State-of-the-Practice Related to QC/QA of Pavement Preservation Treatments

For Quality Control and Quality Assurance practices, District 9 has internal checklists that they use to ensure proper construction and application of their preservation treatments. These checklists can be found in the Appendix of this report and include a

Seal Coat Surface Treatment Equipment Verification Process, a Seal Coat Surface Treatment Checklists (including a Distributor Prep Checklist, a Chipper Spreader Prep Checklist, and a Rubber Tire Roller Checklist), a Seal Coat Preparation Checklist, and a Maintenance Seal Coat Form Program Evaluation Checklist. The district utilizes these checklists to ensure that seal coating treatments are all conducted with the same quality, and all conform to the PennDOT Specification 408.

Identification of Knowledge Gaps and Future Plans

District 9 reported that they believe that the most beneficial aspect of their preservation practices and construction is their calibration days. Their biggest challenge has been due to staff shortages and loss of institutional knowledge between members of their staff. These calibration days have assisted in leveling the knowledge between staff members, and by assisting those with lesser experience to gather insights from those who have more experience.

3.1.2 PennDOT District 10

State-of-the-Practice Related to the Use of Pavement Preservation Treatments

PennDOT District 10 carries out many different types of pavement preservation treatments, including asphalt seal coats, asphalt fog seals, asphalt surface treatments, and micro surfacing treatments. Some of these treatments are performed by contractors, while others are performed by the PennDOT District 10 crews themselves. This choice is generally based on resources. The first limiting resource is equipment, where, for example, the PennDOT District 10 crews do not own the equipment necessary to conduct micro surfacing treatments. In general, seal coating treatments conducted by District 10 are performed by district crews, but one challenge that they sometimes face is staffing issues. District 10 representative stated that performance between those conducted by their crews and by contractors are equivalent in terms of quality of work and that they have not noticed any major differences between the two.

PennDOT District 10 also reported that they sometimes conduct pre-design investigations when performing pavement preservation treatments. They reported that the condition of the pavement is reviewed prior to all treatments, along with the existing pavement design of the roadway.

The representative from PennDOT District 10 stated that their agency conducts most of their seal coating treatments on what they call “pancake” roads. These are roads that are layered on top of layers of asphalt seal coats. After applying a fresh seal coat onto a pancake road, District 10 expects that treatment to last typically 3 to 4 years before cracking occurs. If these roads are not then re-seal coated, water will infiltrate through the surface and will result in a foundation failure. They stated that if these roads were in better condition to begin with, their seal coating treatments would likely last longer. Right now, District 10 is trying to stretch these existing roadways and, therefore, treatments as far as possible. Thus, they have implemented a cyclical maintenance approach in which they have divided their district roadways into quadrants and then one quadrant is treated each year. Thus, every quadrant is treated once every 4 years. This cycle is applicable to all preventative maintenance conducted by PennDOT District 10 or their contractors, including water main replacements.

State-of-the-Practice Related to the Use of Asphalt Seal Coating Treatments

PennDOT District 10 carries out more than 20 asphalt seal coating treatments per year. They generally perform these treatments on both rural and urban local roads and minor collectors, along with rural major collectors. They utilize this treatment to delay or prevent many types of distress, such as fatigue, longitudinal, transverse, and block cracking, along with bleeding, raveling, or a loss of skid resistance. PennDOT District 10 prefers to use polymer modified emulsified asphalt materials in these applications based on their past experiences. They purchase their emulsified asphalt material from their statewide contractors. As for the aggregate material used in seal coating applications, PennDOT District 10 primarily uses washed, virgin aggregate. However, they have experimented with using recycled asphalt pavement (RAP) in these applications as well. They reported that using RAP in seal coating applications leads to having good friction and good aggregate toughness for the surface and that overall, the seal coat performed well. The drawback of using RAP in more seal coating applications was that although it was environmentally friendly, it was not cost-effective as the RAP needed to be crushed and sorted, which is not only expensive but also results in substantial amounts of fines that cannot be incorporated in the seal coat. In addition, the logistics of ensuring that the RAP is not sitting in the truck at the construction site for too long if it is a hot day is another impediment to using RAP. PennDOT District 10 also discussed that granulated slag is an ideal material to be used in seal coating applications. It is very porous and thus provides improved adhesion, along with a high friction surface. The drawback of using granulated slag is that due to its high porosity, it needs to be kept dry, along with the fact that just obtaining the material is difficult in and of itself.

District 10 discussed that in their district they have many roadways that they consider 'pancake' roads. These are pavements with little to no structure and are comprised of layers and layers of seal coats on top of each other. The district has determined that these pancake roads need seal coating treatments on a 4-year cyclic schedule. So, they seal coat all of their roads on a 4-year cyclic schedule. This causes some roadways with traditionally paved structures to be seal coated prior to when it is needed for them. In other words, they could last more than 4 years without reapplication of a seal coat but get treated every 4 years to keep consistent with what the pancake roads are receiving to keep the pattern and the schedule manageable and cost-effective for the district. District 10 suggested that further studies be conducted to collect specific information from different districts on their seal coating practices how they have performed and how much life they have added to both their pancake roads and their roads with traditional pavement structures to determine the cost-benefit analysis of seal coating the pancake roads every 4 years, or seal coating the paved roads every 4 years as well.

District 10 reported that they prefer to apply asphalt seal coating treatments on their roadways because it is quite flexible in nature. They further discussed how seal coats can perform quite well even on pavement that was structurally deficient for up to 3 years due to its flexibility. District 10 further reported that in their seal coating applications, they have primarily only experienced premature failures in these treatments due to not correcting major distresses or underlying weaknesses in the existing pavement before applying the treatment.

State-of-the-Practice Related to the Use of Asphalt Fog Seal Treatments

PennDOT District 10 reported that they do not apply asphalt fog seals as individual preservation treatments and have only experimented with applying them on top of asphalt seal coats. They reported that they tried it on some higher-volume roadways but found that the performance of the seal coat was not increased due to the fog seal. With that, because the fog seal does not provide additional structure or friction to the surface, District 10 has found that this type of treatment is more of a cosmetic application for the people who live nearby and does not provide substantial other benefits. Because of that, District 10 does not apply asphalt fog seals as a common practice.

State-of-the-Practice Related to the Use of Asphalt Surface Treatments

District 10 reported that they commonly conduct asphalt surface treatments (or double seal coats) on "pancake" roads that do not have substantial structure. They further expressed that this double treatment type is especially conducted for roadways that have substantial water underneath the surface or excessive cracking in them, or on roadways with higher ADTs. Although District 10 has used RAP in asphalt seal coating applications, they have not used it in asphalt surface treatment applications. This is simply because they would need to have two separate gradations of the RAP for the first and second layers of the surface treatment, which would provide more work and more challenges to sort the RAP.

When conducting an asphalt surface treatment with two courses with different aggregate sizes, District 10 applies the coarser aggregate layer first and then, approximately six hours later will apply the second, finer aggregate layer of the treatment. When considering when to conduct an asphalt surface treatment over an asphalt seal coat, District 10 primarily considers the surface that the treatment is being applied to and the distresses that exist on it, in addition to the ADT of the roadway that they are applying it to.

State-of-the-Practice Related to Micro-Surfacing Applications

In addition to asphalt seal coats, fog seals, and surface treatments, District 10 also treats some of their pavements with micro surfacing applications to further preserve the structure. These are primarily the 'Type A' micro surfaces, which, as per the PennDOT specification, are used to seal cracks, fill voids, and shallow (less than ½ inch) ruts and provide a scratch course or surface seal. In these micro surfacing applications, District 10 reported that they use either Portland cement or limestone dust as filler material. They said that in their experience when using Portland cement as the filler in a micro surfacing application, the treatment will last for about 7 to 10 years. In comparison, when using limestone dust as the filler in a micro surfacing application, the treatment will last for about 5 to 7 years.

Overall, District 10 reported that the most common cause of failures in their micro surfacing applications has been due to moisture. They reported that proper drainage in the pavement structure, along with conducting patching and crack sealing is essential to ensure good longevity of the micro surface.

State-of-the-Practice Related to Construction Quality Assurance Practice for Pavement Preservation Methods

District 10 reported that they use almost the same quality assurance practices when they conduct a preservation treatment in-house or when they contract out a treatment. The only difference is that the QA is a bit more stringent when performing the treatment in-house since when the work is contracted out, there are also quality control processes in place that are performed by the contractors so the QA can be a bit less stringent.

Identification of Knowledge Gaps and Future Plans

PennDOT District 10 noted that there is a lack of information and research on seal coating practices from a cost-benefit perspective. They noted that they are satisfied with their seal coating practices and methods but would like future studies to focus on when spending the money on a seal coat will be worth it for the pavement, and when it will not be worth it. They suggested that a study could be used to collect data on pavement preservation treatments, the roadways that they are performed on, and the useful life that they are in good condition for to generate a method that can be used by transportation representatives to be able to use the manual and determine which treatment would be the best fit for the roadway that they are trying to treat, and also will be able to be used to estimate the expected life of that treatment.

3.1.3 Pennsylvania Turnpike Commission

State-of-the-Practice Related to the Use of Pavement Preservation Treatments

The Pennsylvania (PA) Turnpike has very high amounts of traffic that travel at very high speeds. Thus, their pavement preservation practices are much different than those of the other municipality agencies or PennDOT agencies discussed throughout this project. The PA Turnpike contracts out most of their treatment applications to be performed by contractors. Their agency crews do seal as needed in their parking lots, as well as conducting crack sealing, or patching, or other smaller treatments. To determine when sections of the turnpike are in need of treatment due to failures in the pavement, the PA Turnpike Commission conducts visual surveys of the pavement two times per year. In addition, they provide the skid resistance and rutting amounts to PennDOT and the FHWA every other year.

The PA Turnpike Commission prefers to conduct repairs or treatments to their pavement that are going to last for a longer duration. And since their roads have such a high amount of traffic, many preservation treatments are not practical to be used in their travel lanes. The Turnpike applies only asphalt seal coats and surface treatments in the shoulders of the pavement, as they are less robust applications that do not have a long duration. In the traveling lanes of the turnpike, the commission conducts both micro surfacing applications and UTBWC applications as preservation treatments for their pavements.

State-of-the-Practice Related to Asphalt Seal Coats (also commonly known as "chip seals") and Asphalt Surface Treatments (also commonly known as "double chip seals")

The PA Turnpike Commission conducts seal coats and surface treatments only on the shoulders of their pavements. These are less robust applications that do not provide additional structural support for the pavement. The turnpike expects only about 3 years out of this type of treatment, but they prefer to conduct treatments that have longer durations. This is a lower cost alternative that does not provide the life that the turnpike needs for roads with such high amounts of traffic on them. In addition, this type of treatment has a higher risk for the turnpike. That is because, in asphalt seal coats and asphalt surface treatments, the aggregate is not generally precoated or premixed with the asphalt material. Thus, the aggregate is generally spread on the pavement, and then the emulsion is sprayed on top of it and then they are rolled to embed the aggregate. Even with the rolling, some aggregate pieces may not be completely embedded. With that, and with cars traveling at very high speeds, any loose aggregate pieces can be dangerous and could fly and break the windshield of a car traveling on the pavement. So, the PA Turnpike Commission is not confident enough to carry out these types of treatments in the travel lanes and instead restricts the use of asphalt seal coats and surface treatments to the shoulders.

When applying asphalt seal coats and surface treatments to the shoulders, the PA Turnpike Commission does not have a set amount of time between applications. They generally expect a life of 3 years from each treatment. That said, the PA Turnpike Commission reported that they would like to apply these treatments more than they do, but when taking funding into account, they have to have the shoulders be less of a priority than maintaining the lanes.

State-of-the-Practice Related to Micro-Surfacing Applications

The PA Turnpike Commission generally conducts double applications of micro surfacing in the lanes of the turnpike when the pavement is oxidized and when they are trying to keep it from spalling or coming apart, while they also do not have the funding to replace the whole wearing course. In these applications, the PA Turnpike uses polymer-modified asphalt emulsion with PG64-22 grade asphalt, following PennDOT Specification 483. In addition, the Turnpike will only use asphalt emulsion producers that have been approved by PennDOT. To conduct the micro surfacing treatment, the pavement must be dry. In the early spring and in late fall conditions, the PA Turnpike Commission does not conduct micro surfacing treatments as the moisture does not get out of the pavement. With the moisture in the pavement, the materials cannot adhere properly to the surface. Thus, the PA Turnpike Commission only applies these treatments under dry conditions. The PA Turnpike Commission reported that they generally use the same contractors for these treatments repeatedly. Because of that, they reported that their micro surfacing treatments generally do not fail before their expected life.

State-of-the-Practice Related to UTBWC

The PA Turnpike Commission applies 6.3-millimeter aggregate courses to their pavements. They use this treatment type in cases when they have a thin depth, and they are unable to change the grade of the roadway. They compared their roadways to many of PennDOT's roads stating that most PennDOT roads have more flexibility in terms of their drainage options as they can have drainage systems that are off the roadway. In comparison, on the Turnpike, there are inlets in the lanes, a guardrail on one side, and a barrier between the two traffic directions. Because of this, if the turnpike were to change the elevations of their roads, there would be many other physical features that they would have to address as well. So, the Turnpike Commission applies thin-wearing courses when they have limited depth that they can mill, and they are still trying to keep the existing elevation. This is a specialized tool that they have in their toolbox; in other words, they do not conduct this type of treatment very often; they only use it for the right case, when they have to. Since this treatment is a thinner course, it will not hold up for the same amount of life as a thicker course would, so it is only used in cases of need, and it is not common for them.

The turnpike has a composite pavement structure, meaning they have concrete slabs that are overlaid by a layer of asphalt. Because of this, many of the primary distresses that they experience at the surface of their pavement and in these thin-wearing courses are due to cracks that propagate at the concrete joints and continue as cracks and weaknesses up through the asphalt. Otherwise, when applying this type of treatment, Turnpike tries hard not to take risks with the public traveling on their roads, so they try to use proven materials, construction methods, etc., to ensure the functionality and performance of their treatments.

State-of-the-Practice Related to Construction Quality Assurance Practice for Pavement Preservation Methods

As any construction work is being done on the Turnpike, the PA Turnpike Commission has inspections at the site while the work is being conducted. They are there to evaluate the work that the contractors are doing. In addition, to assure the quality of the materials being used, the Turnpike Commission takes samples of the materials and brings them back to their laboratories to make sure that they meet the requirements that the contracting company and the Turnpike Commission agreed on. Further, the PA Turnpike Commission has a separate QA unit that conducts spot checks of the inspector's work. This gives the turnpike two layers of assurance and inspection to ensure the good quality of the work they are conducting. Further, every year, the PA Turnpike Commission maintenance forces will walk the roadway. As they walk the roadway, they will seal any cracks that need to be sealed. In addition, if there are areas where patching is necessary, they will conduct the patching as well.

3.1.4 Big Beaver Borough

State-of-the-Practice Related to Pavement Preservation Treatments

Big Beaver Borough applies asphalt seal coats to preserve their municipality roadways. Contractors perform these treatments for the agency. They have found this to be more beneficial because the contractor can provide a better-finished product than they can. The contractors have larger, more improved equipment than the municipality does, allowing for a higher quality of construction. That said, before applying a treatment, someone from the borough walks the entire length of the roadway. They use this to gather a deeper understanding and visual evaluation of the distresses on the roadway. They then determine if they need to add any underdrains or culvert pipes before applying the seal coating treatment.

State-of-the-Practice Related to Asphalt Seal Coat Treatments (also commonly known as "chip seals")

Big Beaver Borough primarily applies asphalt seal coats to correct, further delay, and prevent fatigue cracking, while also using the seal coat to seal the surface of the pavement to prevent water from entering the structure. Before applying a seal coat, Big Beaver Borough patches to correct the surface but does not do any crack sealing to keep costs lower. They have found that most of the smaller cracks seal when the seal coat is applied, but if the cracks are large, the borough will have them milled and patched prior to applying the preservation treatment.

For the material used in asphalt seal coats, Big Beaver Borough determines the type of emulsified asphalt used based on past performance, while following the PennDOT asphalt seal coating specification. This municipality uses washed, virgin aggregate for seal coats, and has not experimented with using precoated aggregate or RAP. The washed virgin aggregate used in these applications is primarily limestone. The municipality reported that in western Pennsylvania, where they are located, the limestone is very soft, and as a result, it polishes quickly. Because of that, the municipality would like to more frequently use slag as an alternative aggregate source, as it was recommended by their contractor based on their past experience. The challenge that the municipality has faced regarding using slag in these operations is finding a PennDOT-approved slag. They reported that if a PennDOT source is not used, they cannot use the liquid fuel taxes funding source, making the preservation treatment more expensive for their municipality.

Big Beaver Borough conducts their seal coating treatments on an as-needed basis, and not on a cyclic schedule. One challenge faced by the municipality regarding their use of these treatments is that for the last approximately 40 years, almost all work done to the roadways has been only applications of asphalt seal coats. As a result, many roads have become very crowded, and their edges are not intact. In addition, some of their older roadways have gotten narrower due to repeat applications of asphalt seal coats. To correct some of these issues, the municipality has been working to rehabilitate these roads in poor condition by employing full-depth reclamation of the pavement and then applying an asphalt seal coat on top of it. Big Beaver Borough has also experienced some instances of 'tar bleeds' resulting from seal coating applications, and they have found the only way to fully correct these bleeds is by performing FDR.

Big Beaver Borough has found asphalt seal coating to be a favorable preservation treatment method due to its low cost, so it is affordable for the municipality. In addition, seal coats are very quick to apply and quick to cure, therefore having minimal disruptions to the traffic. The drawback of using seal coating as their treatment method is that seal coats do not have the longevity that asphalt overlays have.

Part I: Identification of Knowledge Gaps and Future Plans

Big Beaver Borough has been and will continue to contract out the work for their asphalt seal coating applications. They have found that with contractors their treatments will be of a higher quality because the in-house staff will have only limited experience each year operating the equipment and applying the treatments. They have also found contracting out their seal coating treatments to contractors to be beneficial because then the contractor is responsible for the work. So, in instances where a seal coat performs poorly with a life less than what they expected due to an issue during construction, it is the contractors' responsibility to correct that failure.

3.1.5 Cranberry Township

State-of-the-Practice Related to the Use of Pavement Preservation Treatments

Cranberry Township conducts asphalt seal coating and micro surfacing preservation treatments on their roadways. They bid out these projects for contractors to perform. Before conducting these treatments, they always conduct a pre-design investigation to evaluate the pavement that is receiving treatment. Cranberry Township primarily bases its decision on which preservation treatment to implement based on the distresses that exist in the pavement. These distresses, along with the overall conditions of the roadway are tracked and ranked on a roadway management software used by the township. To develop and update the roadway management system, the agency uses RoadBotics by Michelin. RoadBotics drives on the roadways in the township and while driving, they record the road, and their algorithm identifies distresses in the surface and outputs a rating for each of the roads based on the condition of the pavement. Then, that rating is converted to a PASER rating. The PASER rating is then input into their roadway management software called Roadsoft from Michigan Technological University. This software uses GIS mapping tools to display the roadways in the township. The township agency uses the software and inputs the roadway conditions. The map of the roadways in the township is then color-coded based on the condition of the roadway, where the roads in the best condition are shown in green, and the roads in the worst condition are shown in red, etc.

State-of-the-Practice Related to Asphalt Seal Coat Treatments (also commonly known as "chip seals")

To determine when to carry out preservation treatments, Cranberry Township breaks its township into quadrants. They have found that their seal coating treatments last about 3-4 years, so they use the quadrants to divide up the work for each year and seal coat each collector road that needs a seal coat every 4 years. Cranberry Township expressed that they sometimes encounter difficulties and complaints when seal coating on residential roads from the people who live there.

When seal coating, the emulsified asphalt material to be used in Cranberry Township is selected by the contractor who is performing the work but must agree with the PennDOT seal coating specification. Cranberry Township uses washed, virgin aggregate in these applications and primarily uses limestone material.

Cranberry township expressed that their most common cause of failure in their seal coats is due to water entering the structure and causing failures in the base. When the water enters the structure and enters the base and there is a lack of underdrains, the surface of the seal coat will also fail.

State-of-the-Practice Related to Micro-Surfacing Applications

Cranberry Township also conducts micro surfacing treatments on its roadways. In these applications, they primarily use Portland cement as the filler material. They also noted that PennDOT-approved fiber particles to be used in these applications to provide additional strength in the layer. If the structure that is being treated with micro-surfacing treatment is on the borderline of needing and not quite yet needing a base repair, they will introduce fiber matting when applying the micro-surfacing treatment to increase the longevity of the treatment. They have experimented with this and found that the fiber mats have minimized the cracking in the micro surface.

State-of-the-Practice Related to Construction Quality Assurance Practice for Pavement Preservation Methods

Cranberry Township reported that they have not experienced premature failures of their preservation treatments. That said, during the construction of each treatment, the township will collect samples of the emulsified asphalt every day during the construction. They then hold onto the samples of emulsion. If their treatments ever do fail sooner than they were expecting them to, they can use the samples to determine if the failure was caused by the material that was used, or if they need to evaluate other aspects to determine what caused the failure. The township conducts visual evaluations of the distresses in the treated pavements over time to ensure that the treatments are performing as expected.

3.1.6 Potter Township

State-of-the-Practice Related to the Use of Pavement Preservation Treatments

Potter Township carries out asphalt seal coats and occasionally asphalt fog seals to assist in preserving their pavements. Potter Township generally contracts out these treatments as they have found that the contractors have more equipment and are able to be more efficient in the applications. The municipality does conduct crack sealing on their roadways and prefers to apply crack seals within 1-year prior to applying a seal coat and then applies seal coats on an as-needed basis. Potter Township generally considers pavement for a seal coating treatment when it has minor cracking or raveling on the surface, indicating that the pavement has become more porous. The municipality will then apply a seal coating treatment for sealing to prevent water from infiltrating into the structure, and it will also correct some of the surface cracking.

State-of-the-Practice Related to Asphalt Seal Coat Treatments (also commonly known as "chip seals")

As stated above, Potter Township prefers to contract out its asphalt seal coating applications, with a total of approximately 5-10 applications per year. During the applications, the contractor determines their asphalt and aggregate application rates. With that, their contractor uses their own emulsified asphalt material following the PennDOT specifications. They do not use a third-party supplier for the emulsion. In addition, in these applications, washed, virgin aggregate is always used, and they primarily use limestone.

In seal coating applications, Potter Township has found that one common reason why they experience failures earlier than they expected in their seal coat treatments is due to the under-application of the emulsified asphalt material. Because of this, the stone will not have full adhesion to the surface, causing the seal coat to not stay intact. They noted that there are also cases of over-application of emulsion, which provides different challenges, but they tend to experience more issues with the under-application of emulsion or inadequate rolling of the treatment.

Potter Township noted that before their contractors apply an asphalt seal coat, they need to ensure that the surface of the pavement is clean to allow for proper adhesion. In addition, the township does not conduct seal coating treatments if there is rain expected within 24 hours. This allows for proper curing of the material.

State-of-the-Practice Related to Asphalt Fog Sealing Applications

As discussed above, one of the more common premature failures that Potter Township experiences in their seal coats is due to there being not enough emulsion applied to the surface. When this is the case, to remedy it, the township will have an asphalt fog seal applied on top of the seal coat to correct the under-application of emulsion in the seal coat. These applications of fog seals on top of seal coats are only performed on an as-needed basis to assist in keeping the aggregate that was applied during the seal coat adhered to the surface.

State-of-the-Practice Related to Construction Quality Assurance Practice for Pavement Preservation Methods

Potter Township has not had previous experiences where a seal coat in their municipality has failed due to the quality of the materials used in the application. The contractors that they use for these applications are also vendors for PennDOT, so they follow the PennDOT specifications when selecting the material, and it has always performed sufficiently. Because of this, the township does not sample and test the emulsion or aggregate used to ensure its quality as it is the same material PennDOT uses, so they follow PennDOT's use of the material, and if it is okay and used by PennDOT then it is okay and used by them.

Identification of Knowledge Gaps and Future Plans

Potter Township stated that they use asphalt seal coats to seal the surface of roads when they have minor cracking. They further reported that they also sometimes implement seal coating treatments in cases when paving is needed, but it is not affordable for the township at the time. Instead, the township will apply a seal coat to have some more time with the existing roadway before a more substantial rehabilitation or repaving is implemented. However, they primarily use asphalt seal coats to slow down the degradation of their pavements. To evaluate the quality of their treatments, Potter Township inspects their roadways by visual inspection after an application. They are further in the process of getting a GIS system that they will use to track the conditions of their pavements as well as the conditions of these treatments over time.

3.2 CONTRACTOR INTERVIEWS

In addition to the agency interviews that took place, interviews were also conducted with contracting agencies to gather a different perspective regarding seal coating best practices in Pennsylvania. Contractor names and contact information were gathered from the responding transportation entities. One contracting company agreed to be interviewed, Midland Asphalt.

3.2.1 Midland Asphalt

Midland performs many different types of pavement preservation treatments for different municipalities as well as for the state DOT in Pennsylvania. In their seal coating applications, they use a polymer modified CRS-2PM emulsified asphalt material. In general, in their seal coating applications, they use a number 8 aggregate, with 1% of that being washed aggregate. Midland has not conducted any experimentation with using recycled asphalt pavement (RAP) in these seal coating applications. They predict that it will have too much screening to make the RAP the correct size needed. Thus, causing a more time-consuming process.

Midland noted that the most important aspect to ensure a good seal coat is the application. Not only does the pavement need to be in proper condition to receive a seal coat, but in addition it is important that the crew applying the seal coat determines what their pavement needs. They need to determine how oxidized the pavement is to determine the proper amount of emulsion to be used. For example, some pavements are oxidized so much that it causes the emulsion to seep through the pavement structure, preventing the bulk of the oil from remaining on the surface. Further, if the pavement is not allowing the oil to seep into it, then an application of too much emulsion will cause pooling on the surface of the pavement.

Midland reported that the most common cause of failures that they experience in their seal coats is due to using dirty or dusty stones in the application. They stated that even if you have the proper gradation of the stone, the more you handle it or push it into piles, the more dust that it will generate. To avoid this, Midland prefers to precoat its stone. Then, when in piles, the stone does not rub against itself, causing it to form dust, instead the oil touches oil, which does not cause any issues in terms of changing the gradation of the stone.

Midland Construction does conduct quality control practices during all of its applications. Every batch of their materials is sampled and tested for approval of the materials being used. In addition, they invite the state to come visit their labs frequently, to ensure that their production as well as quality control processes are up to the standard of the state.

Midland has also made a switch to incorporate Fibermat into their seal coats as well. They spray an application of emulsion, then apply the Fibermat glass, then spray another application of the emulsion, then spread and roll the aggregate on top of that. The application of the Fibermat increases the life of the seal coat. Midland has also experimented with applying a double seal coat (asphalt surface treatment) with a Fibermat in which they use number 8 aggregate as the first layer, followed by number 9 aggregate as the second layer in addition to the Fibermat. This further increases the life of the seal coat.

The application of the Fibermat prolongs the 'birdbath' coming through, or in other words assists the asphalt layer by preventing ruts or depressions in the surface. Midland reported that their company, along with Russell Standard, performs this type of Fibermat seal coat. They further reported that the Fibermat seal coat costs about 2 times as much as a traditional seal coat does. That said, the advantage of applying the Fibermat then a single chip seal is that it lasts at least 12 years. A traditional chip seal lasts only 3 years in Midland's experience. So, the initial cost is greater for the Fibermat seal coat, but the long-term cost will be less as fewer applications will be necessary to keep the roadway in good condition.

SECTION 4: BEST PRACTICES RECOMMENDATIONS

Throughout the literature review, specification review, Pennsylvania transportation entity survey, and interviews, information was gathered from a wide range of transportation professionals throughout PA to summarize the recommended best practices for asphalt seal coating practices and pavement preservation practices throughout the state. The following lists details some of the reported 'best practices' recommended to all transportation entities, as well as contracting companies, who conduct pavement preservation treatments throughout the state of Pennsylvania:

- It is recommended that transportation entities maintain pavement management systems and use them for the selection and timing of seal coating applications. Existing practices often recommend seal coating at fixed time intervals which may not consider the actual condition and performance of the pavement. Thus, by utilizing pavement management systems, entities can determine the most effective timing for applying seal coating based on pavement conditions and traffic patterns. This approach ensures that seal coating is applied when it is most beneficial, thus maximizing the use of limited resources. Furthermore, it is important to understand that seal coating should be used as a preservation treatment instead of as a "band-aid" or quasi-structural layer. Considering seal coating as a proactive maintenance approach rather than a reactive approach, allows transportation agencies to maintain the structural integrity of the pavement over time.
- The holding of an annual calibration and equipment training day is recommended to be considered by districts and local transportation agencies. Once per year, just before the start of the construction season, transportation entities should conduct these calibration and training days to ensure that all their equipment is in good working order, and to ensure that all of their crew members know how to use all of the equipment. These days can also be used as a day of knowledge transferring from those with more experience to those with less experience to ensure that all applications are conducted in the most effective manner.
- It is further recommended that all transportation entities throughout the state create checklists to be used throughout the construction process. Recommended checklists are as follows: pre-construction checklist, equipment checklist, crew procedures checklist, and post-construction checklist (samples of checklists from PennDOT are attached as appendices to this report). The purpose of creating and using these checklists for all

applications conducted by each agency would be to ensure all treatments are of the best, equivalent quality.

- Based on surveys and interviews of smaller public agencies (such as, smaller townships and cities), use of contractors for application of seal coating projects rather than trying to conduct them in-house may be more beneficial and cost-effective. This is because the contracting companies conduct these treatments more frequently, allowing them to have more experience with higher-quality equipment, generally allowing for a better-quality application.
    - In comparison, it was also recommended that transportation entities conduct their own crack sealing. This is because it is a more simplistic application and treatment type, requiring less equipment. Further, the only way to conduct this treatment type is to walk the roadways. The practice of walking the roadways will allow the transportation entities to have a first-hand visual as to what is happening with their roadways, allowing them to be able to gain a deeper understanding as to what distresses are occurring, allowing them to gain a deeper understanding of what treatment types may be the most effective for each of their roads.
- To ensure timely application of seal coating and to improve the cost-effectiveness with respect to its application, transportation entities are encouraged to track the performance of, as well as treatments to, their roadways through use of pavement management software. Collecting this data will allow the transportation entities to be able to predict when their roadways should receive treatments, which treatments would be most beneficial to apply, as well as to predict how long these treatments should be expected to last.
    - Tracking the treatments as well as the performances of pavements throughout Pennsylvania will allow for further studies to be conducted evaluating which treatments are most effective on which roadways, based on experiences throughout the state.
- From the perspective of seal-coating materials, following best practices are recommended:
    - Continued using CRS-2PM emulsion as it is proven to be effective for seal coating applications.
    - Using precoated aggregates could help keep aggregates dust-free, thus ensuring better adhesion.

    - For better seal coating performance, a two-layer approach using #4 stone on the first lift with #8 stone on the second lift is recommended.
    - Slag has shown very good potential for seal coating when it is kept dry. Therefore, it is encouraged to use it when possible, but ensure that it is in dry state when used.
- Other recommendations with respect to maintenance and preservation of lower volume roadways are following:
    - It is recommended to consider FDR for pavements already treated with multiple applications of seal coating to address potential structural issues.
    - It is also recommended to prioritize drainage repairs and installation to improve seal coating longevity and reduce moisture damage.

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APPENDIX A: ENTITY SURVEY QUESTIONS

The survey questionnaire that was distributed to the PennDOT representatives, along with county and municipality transportation entity representatives is presented in this appendix.

Part A: State-of-the-Practice Related to the Use of Pavement Preservation Treatments

Question 1: Does your agency use (or has recently used within the past 5 years) any of the following pavement preservation treatments? – select all that apply:

- Asphalt seal coat
- Asphalt fog seal
- Asphalt surface treatment
- Slurry seal
- Micro-surfacing
- Ultra-thin bonded wearing course
- Our agency does not implement any of the above pavement preservation treatments
- Other (please specify)

Question 2: At your agency, who generally performs the preservation treatments?

- Contractors only
- Our agency crews only
- Some are performed by contractors, some by our agency crews
- Unknown

Question 3: Please rank the following factors from most considered to least considered, in terms of their importance, when selecting which preservation treatment to implement on a project?

- Specific type of roadway (functional class)
- Existing primary distress(es) present in the pavement
- Existing ride quality of the pavement
- Existing pavement structure (layers and their thicknesses)
- Cost of implementing pavement preservation options
- Other (please specify)

Question 4: Before implementing a pavement preservation treatment, does your agency perform a pre-design investigation? – select best option:

- Yes – always
- Yes – sometimes
- No
- Unknown

Question 5: Each of the pavement preservation treatment types used by your agency are carried-out to delay or prevent which of the following pavement distresses? – select all that apply:

***Survey respondents were prompted to select from the distresses below for each of the preservation treatments that they selected in Question 1.**

- Fatigue (alligator) cracking
- Longitudinal cracking
- Transverse cracking
- Block cracking
- Rutting
- Bleeding
- Raveling
- Loss of skid resistance
- Other (please specify)

Question 6: On which roadway type(s) (functional class) does your agency carry-out each of the following preservation treatments? – select all that apply:

***Survey respondents were prompted to select from the roadway types below for each of the preservation treatments that they selected in Question 1.**

- Rural: Interstate & Freeway
- Urban: Interstate & Freeway
- Rural: Arterial
- Urban: Arterial
- Rural: Major collectors
- Urban: Major collectors
- Rural: Minor collectors
- Urban: Minor collections
- Rural: Local roads
- Urban: Local roads

Part B: State-of-the-Practice Related to Asphalt Seal Coat Treatments (also commonly known as "chip seals")

Question 7: At your agency, approximately how many seal coating applications have you carried out per year (over the last 5 years)? – select best option:

- < 5
- 5 – 10
- 10 – 20
- > 20

Question 8: How does your agency determine the asphalt and aggregate application rates/mix design for a seal coat application?

- McLeod method
- Kearby method
- Application rates are determined by our agency specific mix design method
- Application rates are kept constant for all seal coating projects performed by our agency
- Contractor determines application rates
- Unknown
- Other (please specify)

Question 9: How does your agency determine which type of emulsified asphalt material to use in a seal coating application? – select all that apply:

- Based on past performance
- Based on cost
- Based on availability of material
- Based on historic use
- Based on project needs (i.e. functional class)
- Contractor determines type of emulsified asphalt
- Other (please specify)

Question 10: Which aggregate type does your agency use in seal coat applications? - select all that have been used within the last 5 years:

- Precoated aggregate
- RAP (Recycled Asphalt Pavement)
- Washed aggregate, not precoated and not recycled

Question 11: Which of the following aggregate types are used by your agency in asphalt seal coating applications? – select all that apply:

- Granite
- Limestone
- Quartzite
- Sandstone
- Basalt
- Slate
- Marble
- Gneiss
- Other (please specify)

Question 12: What factors influence your agency's decision to use precoated aggregate in place of not precoated aggregate?

- Based on the properties of the aggregate being used
- Based on the functional class of the roadway
- Based on the existing distresses present in the pavement
- Other (please specify)

Question 13: What is the maximum percentage passing of aggregate material finer than the 75µm (No. 200) (sometimes referred to as fines or dust) sieve allowable by your agency to be used in asphalt seal coating applications?

- 0.5% passing or less
- 1% passing
- 2% passing
- 3% passing
- Greater than 3% passing (please specify allowable maximum percentage)
- Unknown

Question 14: What is the maximum aggregate size for aggregate used in asphalt seal coating applications by your agency?

- 19mm (3/4 inch)
- 12.5mm (1/2 inch)
- 9.5mm (3/8 inch)
- 6.25mm (1/4 inch)
- Unknown
- Other (please specify)

Question 15: What is the maximum abrasion percentage (percentage of loss according to ASTM T 96) or coarse aggregate allowable to be used in seal coating applications by your agency?

- Less than 35% maximum (please specify allowable percentage)
- 40% maximum
- 45% maximum
- 50% maximum
- Greater than 55% maximum (please specify allowable percentage)
- Unknown
- Other (please specify)

Question 16: What ratio of flat and elongated particles does your agency conform to for aggregate used in asphalt seal coating applications?

- 2:1
- 3:1
- 4:1
- 5:1
- Unknown
- Other (please specify)

Question 17: Which types of emulsified asphalt material does your agency commonly use in asphalt seal coating applications? – select all that apply:

- Polymer-Modified Emulsified Asphalt (RS-2PM)
- Polymer-Modified Cationic Emulsified Asphalt (CRS-2PM)
- Polymer-Modified High Float Emulsified Asphalt (HFRS-2PM)
- Emulsified Asphalt (RS-2)
- Cationic Emulsified Asphalt (CRS-2)
- High-Float Emulsified Asphalt (HFRS-2)
- Other (please specify)

Question 18: Are application timings during construction of seal coats constant for all seal coats implemented by your agency?

- Yes, application timing are determined by our agency and are kept constant during all seal coating applications
- No, application timings are determined by our agency on a project-by-project basis

- Application timings are determined by the contractor

Question 19: Immediately after applying a seal coat, is traffic permitted to drive on the pavement?

- Yes, traffic is immediately permitted as usual on the pavement and can travel at usual speeds
- Yes, traffic is immediately permitted on the pavement but with a pilot car, and must travel at ___mph (please specify allowable speed in the box provided)
- No, traffic is not permitted to drive on the pavement immediately. Traffic cannot drive on the pavement until ___hours after the application (please specify the time in the box provided)
- Unknown
- Other (please specify)

Question 20: How long after a seal coat application is traffic able to resume as usual, at normal on the treated surface?

- After < 2 hours
- After 2-4 hours
- After 5-6 hours
- After > 6 hours
- Other (please specify)

Question 21: After the application of a seal coating treatment, does your agency perform post-construction testing to determine the percent embedment of the aggregate in the asphalt?

- Yes, please specify what method is used: (please specify in box provided)
- No, our agency does not evaluate the percent embedment after application
- Unknown

Question 22: Does your agency apply fog seals on top of seal coats?

- Yes, always
- Yes, sometimes
- No, never

Question 23: About how long after seal coat applications is a fog seal application generally applied?

- Immediately after seal coat construction

- 1 day after seal coat construction
- < 1 week after seal coat construction
- 1 – 3 weeks after seal coat construction
- 4 – 6 weeks after seal coat construction
- > 6 weeks after seal coat construction

Question 24: How does your agency determine when to apply asphalt seal coats?

- As needed, based on the distresses present in the pavement
- On a cyclical maintenance program, on average seal coats are reapplied to the same pavement every ___ years (please provide the time in the box provided)
- Unknown
- Other (please specify)

Question 25: Approximately how long does your agency expect a seal coating treatment life expectancy to be?

- 3 years of less
- 4 – 6 years
- 7 – 9 years
- 10 years or more
- Other (please specify)

Question 26: What is the most common cause of failures in asphalt seal coat applications that your agency implements?

- Poor material selection
- Poor quality of construction
- Poor application timing
- Traffic permitted on surface before proper curing of treatment
- Failure due to distresses in the existing pavement
- Factors not preventable by mix design or construction process (i.e. weather or increased traffic)
- Asphalt seal coats implemented by our agency generally do not fail before their expected life
- Unknown
- Other (please specify)

Part C: State-of-the-Practice Related to Asphalt Fog Seals

Question 27: Does your agency apply asphalt fog seals on top of seal coats or does your agency apply fog seals as independent preservation treatments?

- Our agency applies asphalt fog seals on top of asphalt seal coats
- Our agency applies asphalt fog seals as independent preservation treatments
- Our agency applies fog seals both on top of asphalt seal coats and as independent preservation treatments

Question 28: At your agency, approximately how many asphalt fog seal applications have you carried out per year (over the last 5 years)? – select best option:

- < 5
- 5 – 10
- 10 – 20
- > 20

Question 29: How does your agency determine when to apply fine aggregate in addition to the asphalt material, during a fog sealing application?

- Our agency always applies fine aggregate in addition to the asphalt material in fog sealing applications
- Based on the functional class of the roadway
- Based on the existing distresses present in the pavement
- Based on other criteria (please specify)
- Our agency never applies fine aggregate in addition to the asphalt material in fog sealing applications

Question 30: How does your agency determine the asphalt and/or fine aggregate application rates for a fog sealing application?

- Application rates are determined by our agency specific design method, and are determined on a project-by-project basis
- Application rates are kept constant for all fog sealing projects performed by our agency
- Contractor determines application rates
- Unknown
- Other (please specify)

Question 31: Are application timings during construction of fog seals constant for all fog seals implemented by your agency?

- Yes, application timings are determined by our agency and are kept constant during all fog sealing applications
- No, application timings are determined by our agency on a project-by-project basis
- Application timings are determined by the contractor

Question 32: Immediately after applying a fog seal, is traffic permitted to drive on the pavement?

- Yes, traffic is immediately permitted as usual on the pavement and can travel at usual speeds
- Yes, traffic is immediately permitted on the pavement but with a pilot car, and must travel at ___mph (please specify allowable speed in the box provided)
- No, traffic is not permitted to drive on the pavement immediately. Traffic cannot drive on the pavement until ___hours after the application (please specify the time in the box provided)
- Unknown
- Other (please specify)

Question 33: How long after a fog seal application is traffic able to resume as usual, at normal on the treated surface?

- After < 2 hours
- After 2 – 4 hours
- After 5 – 6 hours
- After > 6 hours
- Other (please specify)

Question 34: Approximately how long does your agency expect a fog sealing treatment life expectancy to be?

- 3 years of less
- 4 – 6 years
- 7 – 9 years
- 10 years or more
- Other (please specify)

Question 35: What is the most common cause of failures in asphalt fog seal applications that your agency implements?

- Poor material selection

- Poor quality of construction
- Poor application timing
- Traffic permitted on surface before proper curing of treatment
- Failure due to distresses in the existing pavement
- Factors not preventable by mix design or construction process (i.e. weather or increased traffic)
- Asphalt fog seals implemented by our agency do not fail before their expected life
- Unknown
- Other (please specify)

Part D: State-of-the-Practice Related to Asphalt Surface Treatments (also commonly known as "double chip seals"

Question 36: At your agency, approximately how many asphalt surface treatment applications have you carried out per year (over the last 5 years)? – select best option:

- < 5
- 5 – 10
- 10 – 20
- > 20

Question 37: When constructing an asphalt surface treatment, what is the primary reason that your agency decides to use this treatment type in place of an asphalt seal coat treatment?

- Functional class of the roadway
- Existing condition of the roadway (existing distresses)
- Unknown
- Other (please specify)

Question 38: During the application of an asphalt surface treatment, how long after the first application is the second application generally applied?

- 1 hour or less after the first application
- 2 – 3 hours after the first application
- 4 – 5 hours after the first application
- > 1 day after the first application
- Other (please specify)

Question 39: How does your agency determine the asphalt and aggregate application rates/mix design for an asphalt surface treatment application?

- Application rates are determined by our agency specific mix design method
- Application rates are kept constant for all asphalt surface treatment projects performed by our agency
- Contractor determines application rates
- Unknown
- Other (please specify)

Question 40: How does your agency determine which type of emulsified asphalt material to use in an asphalt surface treatment application? – select all that apply:

- Based on past performance
- Based on cost
- Based on availability of material
- Based on historic use
- Based on project needs (i.e. functional class)

Question 41: Which aggregate type does your agency use in an asphalt surface treatment application? – select all that have been used within the last 5 years:

- Precoated aggregate
- RAP (Recycled Asphalt Pavement)
- Washed aggregate, not precoated and not recycled

Question 42: What factors influence your agency's decision to use precoated aggregate in place of not precoated aggregate during an asphalt surface treatment application?

- Based on the properties of the aggregate being used
- Based on the functional class of the roadway
- Based on the existing distresses present in the pavement
- Other (please specify)

Question 43: Are application timings during construction of asphalt surface treatments constant for all asphalt surface treatments implemented by your agency?

- Yes, application timings were determined by our agency and are kept constant for all asphalt surface treatments implemented by our agency
- No, application timings are determined by our agency on a project-by-project basis

- Application timings are determined by the contractor

Question 44: After the first application of asphalt and aggregate during an asphalt surface treatment, how is it determined when the second application of asphalt and aggregate can be applied?

- It is determined by our agency based on the percent embedment
- It is a standard amount of time, determined by our agency, across all asphalt surface treatment applications
- It is determined by our agency based on another factor (please specify)
- It is determined by the contractor
- Other (please specify)

Question 45: Immediately after applying an asphalt surface treatment, is traffic permitted to drive on the pavement?

- Yes, traffic is immediately permitted as usual on the pavement and can travel at usual speeds
- Yes, traffic is immediately permitted on the pavement with a pilot car, and must travel at ___ (speed, mph)
- No, traffic is not permitted to drive on the pavement immediately. Traffic cannot drive on the pavement until ___ (time, hours) after the application
- Unknown
- Other (please specify)

Question 46: How long after an asphalt surface treatment application is traffic able to resume as usual, at normal on the treated surface?

- After < 2 hours
- After 2 – 4 hours
- After 5 – 6 hours
- After > 6 hours
- Other (please specify)

Question 47: After the application of an asphalt surface treatment, does your agency perform post-construction testing to determine the percent embedment of the aggregate in the asphalt?

- Yes, please specify what method is used (please specify)
- No, our agency does not evaluate the percent embedment after application
- Unknown

Question 48: Approximately how long does your agency expect an asphalt surface treatment life expectancy to be?

- 3 years or less
- 4 – 6 years
- 7 – 9 years
- 10 years or more
- Other (please specify)

Question 49: What is the most common cause of failures in asphalt surface treatment applications that your agency implements?

- Poor material selection
- Poor quality of construction
- Poor application timing
- Traffic permitted on surface before proper curing of treatment
- Failure due to distresses in the existing pavement
- Factors not preventable by mix design or construction process (i.e. weather or increased traffic)
- Asphalt surface treatments implemented by our agency generally do not fail before their expected life
- Unknown
- Other (please specify)

Part E: State-of-the-Practice Related to Slurry Seals

Question 50: At your agency, approximately how many slurry seal applications have you carried out per year (over the last 5 years)? – select best option:

- < 5
- 5 – 10
- 10 – 20
- > 20

Question 51: What is the most common type of slurry seal implemented by your agency?

- Type I: Used to seal cracks, fill voids, and correct surface erosion
- Type II: Used to fill surface voids, correct severe surface erosion conditions, and provide a minimum wearing surface

- Type III: Used to provide a new moderate wearing surface or to build up a crown
- Other (please specify)

Question 52: How does your agency determine which type of emulsified asphalt material to use in a slurry seal application? – select all that apply:

- Based on past performance
- Based on cost
- Based on availability of material
- Based on historic use
- Based on project needs (i.e. functional class)
- Contractor determines type of emulsified asphalt
- Other (please specify)

Question 53: How does your agency determine which type of filler to use in a slurry seal application? – select all that apply:

- Based on past performance
- Based on cost
- Based on availability of material
- Based on historic use
- Based on project needs (i.e. functional class)
- Contractor determine type of filler
- Other (please specify)

Question 54: Which types of filler has your agency used in slurry seal applications in the past 5 years? – select all that apply:

- Portland cement
- Hydrated lime
- Limestone dust
- Fly ash
- Other (please specify)

Question 55: How is the mixture composition of a slurry seal determined by your agency?

- Our agency designs and tests the slurry seal mixture according to ASTM D 3910
- Our agency designs and tests the slurry seal according to our own agency design specification

- The contractor performs the design and testing during slurry seal applications
- Other (please specify)

Question 56: How is the application rate of the dry aggregate during a slurry seal application determined by your agency?

- Dry aggregate application rate is selected by our agency and is constant for each slurry seal type across all projects
- Dry aggregate application rate is determined by our agency on a project-by-project basis
- Dry aggregate application rate is determined by the contractor
- Other (please specify)

Question 57: Approximately how long does your agency predict the life expectancy of a slurry seal application to be?

- 3 years or less
- 4 – 6 years
- 7 – 9 years
- 10 years or more
- Other (please specify)

Question 58: What is the most common cause of failures in slurry seal applications that your agency implements?

- Poor material selection
- Poor quality of construction
- Poor application timing
- Traffic permitted on surface before proper curing of treatment
- Failure due to distresses in the existing pavement
- Factors not preventable by mix design or construction process (i.e. weather or increased traffic)
- Slurry seals implemented by our agency generally do not fail before their expected life
- Unknown
- Other (please specify)

Part F: State-of-the-Practice Related to Micro Surfacing Applications

Question 59: Approximately how many micro surfacing applications has your agency carried out per year (over the last 5 years)? – select best option:

- 5 or fewer
- 5 – 10
- 10 – 20
- 20 or more

Question 60: What is the most common type of micro surfacing application implemented by your agency?

- Type A: Used to seal cracks, fill voids and shallow (less than ½ inch) ruts, and provide a scratch course or surface seal
- Type B: Used to fill moderate (1/2 to 1-1/4 inch) ruts; and provide a scratch course, a leveling course, a seal coat, or a surface treatment
- Type Rut Fill (RF): Used to fill deep (2 inch) ruts in a single pass
- Other (please specify)

Question 61: How does your agency determine which type of emulsified asphalt material to use in a micro surfacing application? – select all that apply:

- Based on past performance
- Based on cost
- Based on availability of material
- Based on historic use
- Based on project needs (i.e. functional class)
- Contractor determines type of emulsified asphalt
- Other (please specify)

Question 62: How does your agency determine which type of filler to use in a micro surfacing application? – select all that apply:

- Based on past performance
- Based on cost
- Based on availability of material
- Based on historic use
- Based on project needs (i.e. functional class)
- Contractor determines type of filler
- Other (please specify)

Question 63: Which types of filler has your agency used in micro surfacing applications in the past 5 years? – select all that apply:

- Portland cement

- Hydrated lime
- Limestone dust
- Fly ash
- Other (please specify)

Question 64: How is the mixture composition of a micro surfacing application determined by your agency?

- Our agency designs and tests the micro surfacing mixture to satisfy the mixture composition requirements outlines in PennDOT Specification Section 483
- Our agency designs and tests the micro surfacing mixture according to our own agency design specification
- The contractor performs the design and testing during micro surfacing applications
- Other (please specify)

Question 65: How is the application rate of a micro surfacing application determined by your agency?

- Micro surfacing application rates are constant (for each type) across all projects performed by our agency
- Micro surfacing application rates are determined on a project-by-project basis by our agency
- The contractor determines the micro surfacing application rate for each project
- Other (please specify)

Question 66: Approximately how long does your agency predict the life expectancy of a micro surfacing application to be?

- 3 years or less
- 4 – 6 years
- 7 – 9 years
- 10 years or more
- Other (please specify)

Question 67: What is the most common cause of failures in micro surfacing applications that your agency implements?

- Poor material selection
- Poor quality of construction
- Poor application timing

- Traffic permitted on surface before proper curing of treatment
- Failure due to distresses in the existing pavement
- Factors not preventable by mix design or construction process (i.e. weather or increased traffic)
- Micro surfacing applications implemented by our agency generally do not fail before their expected life
- Unknown
- Other (please specify)

Part G: State-of-the-Practice Related to Ultra-Thin Bonded Wearing Courses (UTBWC)

Question 68: Approximately how many UTBWC applications have been carries out by your agency per year (over the last 5 years)? – select best option:

- 5 or fewer
- 5 – 10
- 10 – 20
- 20 or more

Question 69: When applying an UTBWC, how is the tack coat application rate determined by your agency?

- It is a uniform rate for all projects of this type implemented by our agency. The rate used is ___ (rate, units).
- The application rate of the tack coat is determined on a project-by-project basis. Please specify methods used (please specify)
- The application rate is determined by the contractor
- Other (please specify)

Question 70: How is the mixture composition of an UTBWC application determined by your agency?

- Our agency designs and tests the UTBWC mixture to satisfy the mixture composition/characteristic requirements outlines in PennDOT Specification Section 489
- Our agency designs and tests the UTBWC mixture according to our own agency design specification
- The contractor performs the design and testing during UTBWC applications
- Other (please specify)

Question 71: What is the typical thickness (or range of thicknesses) of UTBWC applied by your agency?

- (please specify approximate thickness and units)

Question 72: Approximately how long does your agency predict the life expectancy of an UTBWC application to be?

- 3 years or less
- 4 – 6 years
- 7 – 9 years
- 10 years or more
- Other (please specify)

Question 73: What is the most common cause of failures in UTBWC applications that your agency implements?

- Poor material selection
- Poor quality of construction
- Poor application timing
- Traffic permitted on surface before proper curing of treatment
- Failure due to distresses in the existing pavement
- Factors not preventable by mix design or construction process (i.e. weather or increased traffic)
- UTBWC applications implemented by our agency general do not fail before their expected life
- Unknown
- Other (please specify)

Part H: State-of-the-Practice Related to Construction Quality Assurance Practices for Pavement Preservation Methods

Question 74: What parameters are evaluated as part of contractor QC process during construction of pavement preservation treatments?

- Sampling and testing of emulsified asphalt material
- Sampling and testing of aggregate
- Validating asphalt application rates
- Validating aggregate application rates
- Other (please specify)

Question 75: After the application of a pavement preservation treatment, does your agency perform post-construction testing to determine quality of the treatment?

- Yes, please specify what methods are used (please specify)
- No, our agency does not evaluate preservation treatments after application
- Unknown
- Other (please specify)

Question 76: Does your agency evaluate the performance of pavement preservation treatments over time? – select all that apply:

- Yes, with visual evaluation of distresses over time
- Yes, with evaluation of ride quality
- No performance evaluation conducted
- Other (please specify)

Question 77: Prior to the application of a pavement preservation treatment, does your agency routinely utilize any treatments to reduce the potential for cracking in the treatment? – select all that apply:

- Crack sealing
- Patching
- Our agency does not apply treatments to reduce cracking in surface treatments
- Other (please specify)

Question 78: Does your agency employ any efforts or plan to employ any efforts to quantify the environmental, economic, or ecological impacts (sustainability) of implementing preservation treatments? – select all that apply:

- Life cycle analysis
- Life cycle cost analysis
- We do not quantify the sustainability of pavement preservation treatments
- Unknown
- Other (please specify)

Part I: Identification of Knowledge Gaps and Future Plans

Question 79: Have you observed any gaps in knowledge or roadblocks that have made it challenging for your agency to start (or continue) successfully implementing pavement preservation treatments? – select all that apply:

- Lack of agency experience

- Lack of contractors' expertise in performing certain treatments
- Lack of mix design methods and engineering-based design procedures
- Lack of tests and criteria to determine which preservation treatment to implement
- Poor performance of past pavements that received a preservation treatment
- No significant roadblocks
- Other (please specify)

Question 80: Does your agency have plans to carry-out pavement preservation treatments in future projects?

- Yes (please briefly describe which treatments and how many of each are planned)
- No
- Unknown

Question 81: This project will also include case examples illustrating agency practices of preservation treatments. The development of the case example(s) will require an additional follow-up interview. Agencies will be provided the opportunity to review the case example write-up for accuracy. Would your agency be willing to participate as a case example?

- Yes
- No

If you have any additional information or thoughts your would like to share regarding this topic, please do so here:

- (please explain)

END OF SURVEY

APPENDIX B: PENNDOT SEAL COAT SURFACE TREATMENT EQUIPMENT VERIFICATION PROCESS

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.penndot.gov

SEAL COAT SURFACE TREATMENT EQUIPMENT VERIFICATION PROCESS

Distributors, Chip Spreaders, and Rubber Tire Rollers are the three main pieces of equipment involved in surface treatments or seal coat projects. For successful material application, it is crucial that each piece of equipment is verified to be fully functional and operating efficiently. This document outlines the verification requirements and procedures, and copies are to be made available on-site when performing seal coat / surface treatment assemblies.

Chip Spreader (Chipper) Verification Process: (Form M-214C)

A properly verified chip spreader will be capable of applying the aggregate to the roadway at selected application rates according to the design or field adjusted rates. The chip spreader will go through two verification processes as follows. Ground speed test, to ensure the equipment is reading the correct distance to ensure accurate application rates. Proper aggregate yield is expressed in pounds per square yard. Both processes need to work as designed to complete a quality process.

Ground Speed Test:

1. Load a dump truck with the aggregate specified for the assembly and connect it to the chip spreader.
2. Bring the chip spreader up to the desired speed (as expressed in feet per minute), on cue dispense a single two second (2) application of aggregate.
3. After traveling for a time of one minute (1) dispense another two second (2) application of aggregate.
4. Measure the distance from the beginning of the first shot of aggregate to the beginning of the second application of aggregate; this will be expressed as a distance in feet traveled per minute.
5. If the measured distance is greater than (>) 10' (feet) from the set distance on the machine, this must be reported to the equipment manager.

Several different distances should be reviewed to ensure the machine will function as desired. Record each distance on the form attached and save these settings for future use.

Aggregate Yield:

1. Load a dump truck with the aggregate specified for the assembly and hook it into the chip spreader.
2. Place a one (1) square yard drop cloth (36" X 36") approximately 100 to 150 feet in front of the chip spreader.
3. Bring the chip spreader up to speed and open the gates as it passes over the drop cloth and dispense aggregate onto the drop cloth, immediately close the gates after passing over the drop cloth.
4. Pick up the cloth with the aggregate inside being careful not to lose any material. Weigh the cloth and aggregate on a calibrated scale.
5. Subtracting the weight of the drop cloth from the total weight calculates the yield in pounds per square yard.
6. Record this on the form attached.
7. If the weight of the material does not match that as set for this gate setting, adjustments need to be made and the test re-run.
8. On variable width head machines it is recommended to verify both the left and right side of the machine.
9. Several different settings should be reviewed and the results saved into the machine for future adjustments as needed.

This concludes the chip spreader verification process. A form is attached to record the information and must be present on site while performing this assembly.

Oil Distributor Verification Process and Documentation: (Form M-214D)

A properly verified oil distributor will be capable of applying the liquid bituminous to the roadway at selected application rates according to the design or field adjusted rates. The distributor will go through three verification processes as follows. Gallons per minute test, this will determine what the pump is able to do and preform at a given application rate. Ground speed test, to ensure the equipment is reading correct distance which ensures accurate application rates. Triple lap coverage, this is to ensure an adequate amount of oil is placed on the roadway to achieve proper application rates. All three processes need to work as designed to complete a quality process.

Warm Up Process:

1. Record the type and temperature of the oil to be used during the verification. The oil shall be within the application temperature range as it appears on the bill of lading. Position the empty distributor on a relatively smooth, level surface near a source of supply. Pump approximately 200 gallons into the distributor to warm up the pump.

2. Record the quantity in the distributor as indicated by the use of the calibrated measuring stick supplied with the distributor and indicated by the tank gauge.
3. Indicate whether or not the tank gauge was adjusted or reset to equal the stick reading.

Gallons per Minute Test:

1. Set the asphalt pump tachometer or gallons per minute meter to 100 Gals./Min.
2. Record the gallons of oil indicated by the stick measurement in the pre-test warm up in the "Beginning Gallons" section of the form provided.
3. On cue, pump oil from the source of supply to the distributor for six minutes. Six minutes is the recommended duration of the test, an alternate duration may be used.
4. At the end of the timed pump, record both the stick measurement and tank gauge readings as the "Gallons ending."
5. Calculate and record the total gallons pumped by subtracting the gallons beginning from the stick measured gallons ending.
6. Record the actual minutes of the test duration.
7. Divide total gallons pumped by the test duration time in minutes to calculate and record the 'Gallons per Minute."
8. Indicate whether or not the tank gauge matches the stick measurement.
9. This concludes the gallons per minute test with the asphalt tachometer set at 100 Gals./Min. To further verify the resultant yield in the gallons per minute, it may be necessary to repeat this process with the asphalt tachometer set at 125 Gals./Min and again at 150 Gals./Min. The gallons beginning for each subsequent test will equal the stick measured gallons ending of the previous test.
10. At this point you may want to measure the spray bar height, both left and right as the distributor is approximately 1/2 full.
11. If the calculated gallons per minute deviates more than "five" (5) gallons from the asphalt pump tachometer setting, this information shall be reported to the equipment manager.

Ground Speed Test:

1. Set the bitumeter or feet per minute meter to 300' (feet) per minute.
2. Accelerate the distributor to 300' per minute and once up to speed. On cue, dispense a one (1) second shot of oil. It should be noted that only a small section of the spray bar may be used for this test.
3. Traveling at a constant speed of 300 feet per minute, dispense another one (1) second shot of oil after exactly one minute of time has lapsed from the first shot. It is recommended to use a stop watch to accurately time this test.
4. Measure and record the distance from the beginning of the first shot of oil to the beginning of the second shot of oil.
5. Record the difference between the measured distance and the bitumeter setting. Differences greater than ten (10) feet shall be reported to the equipment manager.
6. This concludes the ground speed test with the bitumeter set at 300 feet per min. To further verify the results, it may be necessary to repeat this process with the bitumeter set at 350', 400' and again at 450' per minute.

Triple Lap Coverage Test:

1. Record the quantity, type and temperature of the oil in the distributor at the time of the test.
2. Set the pump for five (5) gallons per minute for each foot of bar.
3. Shut off all nozzles, with the exception of the last three feet of one end of the spray bar, for pressure relief. Now manually turn on every third (3rd) nozzle for the remainder of the spray bar.
4. After making a short shot to warm the bar and ensure oil flows and a pattern is present, make another short shot of oil and review the pattern of the oil. Streaking of the oil (areas without oil) could indicate the spray bar is too low and would need to be raised slightly. An overlap pattern (areas where the oil is too heavy) where the spray fans are passing over each other, in which case the bar may be too high and needs to be lowered. Several attempts or passes may need to be made to ensure the spray pattern just touches that of the nozzle beside it.
5. Record the height of the spray bar, both left and right, when the spray fans just touch each other. This measurement should be taken at a location where the distributor and the spray bar are level across its entire length. This is then known as the set-up height of the spray bar.

This concludes the distributor verification process. A form is attached to record the information and must be present on site while preforming this assembly.

Rubber Tire Roller Verification Process, Dry Print Tracking Test: (Form M-214E)
A properly verified roller will ensure all tires on the roller are applying appropriate ground contact pressure to the surface. To ensure all tires are properly inflated, so a complete surface coverage can be obtained, the following process should be followed.

Dry Print Test:

To begin the test, you will need a tire pressure gauge, air supply, table or bound computer paper and a relatively flat and dry surface. Verify the ply rating and air pressure in all tires, inspect all tires for defects or badly worn tires, replace as needed. From the chart attached to the machine, find the tire pressure corresponding to the 40 – 50 pounds per square inch (psi) requirement. This is the starting point for this machine to achieve full width coverage.

1. From the roller, find and record the corresponding air pressure for the tires to achieve 40 – 50 psi ground contact.
2. Verify that all tires are inflated to the correct air pressure starting point.
3. Check all Scrappers and Pads.
4. Place the paper on a dry flat surface, properly securing the outside edges of the paper from movement.
5. Drive the roller on a dry area, allowing the tires pick up dust.
6. Have the roller pass over the paper in a straight path, with no turning movements.
7. Observe the wheel tracks left from the tires on the paper: no streaking should be observed.
8. If streaking is present, a reduction in tire pressure may be required.
9. **Note: Observe all manufacturers requirements for tire air pressure.** This is for the stability of the machine.
10. If possible, reduce tire pressure by 3 pound increments in all tires.
11. Rerun the dry print test again, observing for streaking.
12. When no streaking is present, check the air pressure in all tires and record this as the “adjusted air pressure.”
13. The dry print tracking paper needs to be dated and retained with the equipment manager for the season, and does not have to be on site. The form for each roller must be on site while performing this assembly.

** NOTE: Reducing the air pressure below the manufacturer’s recommended minimum will adversely affect the lateral stability of the roller. Consult the equipment manufacturer if it becomes apparent that tire pressure will have to be reduced to less than 25 PSI to achieve full width tracking coverage.

This concludes the verification process. Copies of the attached documents are required to be on site during this assembly, with the exception of the “dry print paper.”

APPENDIX C: PENNDOT SEAL COAT SURFACE TREATMENT CHECKLISTS

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.penndot.pa.gov

SEAL COAT SURFACE TREATMENT CHECKLISTS

Distributor Prep Checklist

	Verified By	
Item	**Garage**	**Field**
Last Day's 614 report, attached		
Serviced Date to Include Inspection		
Last type of Material on Board		
All In Line Screens Cleaned		
All Bar Air Valves Working		
Nozzles Correct Type and Set to Correct Angle		
All Tank Gate Valves working		
Tank Heaters Working		
Bar Adjustment Devices Cleaned/Working		
Distance Measuring Device Lens Cleaned		
Power to Shot Computer		
Suspension Review		
All Lights Working		
Radio in working order		

A properly repaired distributor will ensure the verification process will flow easily. These are only a few items that should be reviewed and signed off on prior to the verification process beginning. Any items not passing this check list shall be brought to the attention of the equipment manager for repairs.

Chipper Spreader Prep Checklist

	Verified By	
Item	**Garage**	**Field**
Last Day's 614 report, attached		
Serviced Date		
Distance Measuring Device Lens Cleaned		
Power to Shot Computer		
All Air Valves Working		
All gates open and close / greased		
Check all Feeded Belts		
Verify Belt Tracking		
Suspension Review		
All Lights Working		

A properly repaired stone chipper will ensure the verification process will flow easily. These are only a few items that should be reviewed and signed off on prior to the verification process beginning. Any items not passing this check list shall be brought to the attention of the equipment manager for repairs.

Rubber Tire Roller

	Verified By	
Item	Garage	Field
Last Day's 614 report, attached		
Serviced Date		
Distance Measuring Device Lens Cleaned (if Equipped)		
All Tires in Good Condition		
Air Bladder (if equipped) Inflates		
Check all Scrappers and Pads		
Suspension Review		
All Lights Working		

A properly repaired rubber tire roller will ensure the verification process will flow easily. These are only a few items that should be reviewed and signed off on prior to the verification process beginning. Any items not passing this check list shall be brought to the attention of the equipment manager for repairs.

APPENDIX D: PENNDOT SEAL COAT PREPARATION CHECKLIST

M-214G (8-24)

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SEAL COAT (SC) PREPARATION CHECKLIST

TO BE COMPLETED BY AHMM

(Attach additional sheets as necessary)

Calendar Year/Revision:__________/__________ County:

SR	Begin SEG/OFF	End SEG/OFF	Miles	Assembly	Planned Aggregate Tons	Planned Oil Gallons

Prep Item Completed	Yes	No	N/A	Date Planned	Comments
Pipe Cleaning (Flushing)	☐	☐	☐		
Ditching/Tail Ditching	☐	☐	☐		
Pipe Replacement	☐	☐	☐		
Inlet/Endwall Repair	☐	☐	☐		
Shoulder Cutting/Side Dozing	☐	☐	☐		
Crack Sealing	☐	☐	☐		
Edge Patching/Widening	☐	☐	☐		
Trench Restoration	☐	☐	☐		
Base Repair	☐	☐	☐		
Manual Patching	☐	☐	☐		
Brushing / Mowing	☐	☐	☐		

Select "Yes" if this preparatory item has been completed on the roadway prior to this seal coat cycle. Any items checked "No" require a comment. Select "N/A" if preparatory item is not needed or warranted on the roadway.

PLANNING ITEMS	Yes	No	N/A
Application reviewed as proper resurfacing treatment	☐	☐	
Material quantity and types verified with the RPC	☐	☐	
Potential project conflicts coordinated with other District Units (i.e. Municipal Services, Permits, Traffic Services, Utilities, etc.)	☐	☐	
Pavement marking inventoried and coordinated with District Traffic Unit	☐	☐	
Railroad Crossings - limits identified and coordinated with RR Coordinator	☐	☐	☐
P3 bridge(s) located within the SC Project and documentation included in SC binder	☐	☐	☐

Comments:

Reviewed By: ______________________________ Date:__________
(AHMM)

Submitted By: ______________________________ Date:__________
(HMM)

Photos (Optional)

Photos (Optional)

APPENDIX E: PENNDOT MAINTENANCE SEAL COAT FORM PROGRAM EVALUATION CHECKLIST

M-214H (2-23)

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MAINTENANCE SEAL COAT FORM
Program Evaluation Checklist
(TO BE COMPLETED BY District/Central Office personnel)

DATE:	EVALUATOR NAME/EVAL. ORG.:	COUNTY EVALUATED:	STATE ROUTES EVALUATED:

CERTIFICATIONS (Pub 408 & Pub 23) **All materials certifications documented and on file**	**YES**	**NO**	**N/A**
Certifications are on file for material used. (Form CS 4171)			
PROJECT DOCUMENTATION (Pub 408 & Pub 23) **Documentation applicable to this operation current, properly completed, and on file.**	**YES**	**NO**	**N/A**
QC plan minimum requirements met and all accompanying documentation attached.			
Necessary employees received Surface Improvement Training training within the past 4 years and documentation is on file.			
Aggregate contract purchase order matches or exceeds the SRL value specified for the roadway ADT.			
Form M-214F, Daily Reporting - Seal Coats and Surface Treatments Form, completed daily and kept on file.			
AHMM completed Form M-214G, Seal Coat Preparation Checklist.			
Did county conduct a pre-operation meeting?			
MATERIALS TEST DOCUMENTATION (Pub 408) **All testing properly performed and documented.**	**YES**	**NO**	**N/A**
Gradation results properly documented on file.			
Compatibility results properly documented and on file.			
Emulsion samples properly documented.			
When required, Form TR 447 is completed and on file for any emulsion samples sent to lab.			
Dispostition of rejected material documented.			
If conventional oil used, written approval granted by District Executive on file.			
EQUIPMENT DOCUMENTATION (Pub 408) **All equipment verification performed and properly documented.**	**YES**	**NO**	**N/A**
Form M-214B, Seal Coat Surface Treatment Checklist, has been completed and documentation is on file for all equipment used in seal coat operations.			
All chippers used during operations have been properly verified as outlined in Form M-214A, Seal Coat Treatment Equipment Verification Process and documented using Form M-214C, Chip Spreader Verification.			
All oil distributors used during opeartions have been properly verified as outlined in Form M-214A, Seal Coat Treatment Equipment Verification Process and documented using Form M-214D, Oil Distributor Verification.			
All rubber tire rollers used during operations have been properly verified as outlined in Form M-214A, Seal Coat Treatment Equipment Verification Process and documented using Form M-214E, Rubber Tire Roller Verification.			
SEASONAL LIMITATIONS (Pub 408) **Placement as per time of year limitations.**	**YES**	**NO**	**N/A**
Seal Coats/Surface Treatments placed within the seasonal limitations as outlined in PUB 408, unless an extension of the surface treatment season is granted in writing by the District Executive; copy of approval on file.			

SIGN AND PAVEMENT MARKING REQUIREMENTS (Pub 23, 213, & 408) **All pre-seal coat operations completed.**	YES	NO	N/A
Temporary Seal Coat signs installed prior to operations as outlined in PUB 213.			
Pavement markings and legends inventoried and documented prior to operations.			
PROJECT COMPLETION AND CLOSEOUT (Pub 23, 113, & 408) **All post-activity operations completed.**	**YES**	**NO**	**N/A**
Roadways swept of excess aggregate.			
Proper overlap at longitudinal joints to avoid gaps in coverage.			
No excess material evident along roadway (excess oil or stone).			
No discernable bumps, smooth transitions to bridge structures and existing pavements. No bumps caused by treatment and end joint is parallel to/matches bridge joint or concrete pavement.			
All pavement markings permanently replaced within 14 days.			
Temporary signing (i.e., No Pavement Markings, Fresh Oil and Chips, etc.) removed in a timely fashion when no longer warranted.			
No visible surface deficiencies, stone loss, flushing, etc. that indicate premature failure of the new seal coat surface. No damage from follow up operations.			
Payroll records of physical limits match the M-213.			
Work Orders/Notification closed (TECO'd) in Plant Maintenance.			
After Action Reviews of seal coat operations held or scheduled.			

EVALUATOR COMMENT SECTION (ANY ITEM CHECKED "NO" REQUIRES A COMMENT AND FOLLOW UP)
CERTIFICATIONS
PROJECT DOCUMENTATION
MATERIAL TEST AND EQUIPMENT DOCUMENTATION
SEASONAL LIMITATIONS
SIGN AND PAVEMENT MARKING REQUIREMENTS
PROJECT COMPLETION AND CLOSEOUT

Photos (Optional)

Photos (Optional)

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Swanson School of Engineering

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