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Alternatives to Seal Coats

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT and the Local Road Research Board. This TRS does not represent the conclusions of Braun Intertec Corporation, MnDOT or LRRB.

Problem Statement

Seal coats are one of many techniques commonly used for asphalt pavement preservation and chip seals are the most commonly used in Minnesota. In some applications, chip seals are not the best surface treatment alternative, such as in areas with frequent or high stress turning movements like cul-de-sacs or intersections, and can suffer chip loss and/or bleeding. The purpose of this Transportation Research Synthesis (TRS) was to summarize current seal coat practices and identify alternatives that provide pavement protection, extend pavement life similar to chip seals, and avoid the identified problems. Other surface treatment techniques used around the country include fog seals, bio seals, sand seals, sandwich seals, slurry seals, and micro surfacing and include many proprietary or brand name products.

Essentially this TRS provides current practices providing the following for city and county engineers:

- Description of the suite of surface treatment alternatives available on the market, and including material properties, costs, and typical life cycles when available. The term ‘life cycle’ is intended to include typical application frequency and the anticipated increase in pavement service life.
- General guidelines to identify current practices and the technique(s) that are best suited for a particular project, including existing pavement condition factors and timing of initial sealing.
- Provide current practices around expected outcomes of the various treatment methods and suggested measurement tool(s) that agencies can use to track surface treatment performance.

Objective

The goal of this project was to summarize the current State of the Practice of surface treatment alternatives to seal coats used in the Midwest and to establish a list of products and techniques for Minnesota cities and counties. Braun Intertec has gathered and summarized information from Midwest agencies, contractors, material suppliers and publications to develop guidelines for project, material, and technique selection.

Scope

This TRS focused on research conducted by other local and state agencies regarding asphalt pavement preservation. Agencies suggested in the initial problem statement included North Dakota, South Dakota, Wisconsin, Illinois, Michigan, Nebraska, the Upper Plains Local Technical Assistance Program (LTAP), and Manitoba's Department of Roads. The report summarizes how various treatment methods are selected and their effectiveness and expected service life.

This project aimed to provide a clear picture of effectiveness, costs and application techniques for alternative seal coat methods. A successful alternative was defined as a seal that:

- Minimizes impacts to the traveling public and adjacent homeowners in urban areas;
- Works well in locations with excessive turning movements, such as cul-de-sacs, parking lots, trails, and other areas where cities and counties historically have difficulty laying chip seals;
- Produces similar benefits as a chip seal but does not require cover aggregate;
- Is resistant to scraping or abrasion from carbide snow plow blades (particularly at street centerlines);
- Has a fast curing time; and
- Can be spray applied.

The following factors are included to aid city and county engineers make decisions of alternative(s) that are best-suited for their network, maintenance staff, and equipment capabilities:

- Material costs;
- Application labor costs; and
- Application frequency/service life.

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Literature Review

Pavement preservation treatments restore pavement surface conditions and protect the underlying pavement, which can defer the need to rehabilitate or reconstruct pavements. These benefits can lead to great cost savings. The proverb commonly cited to effectively apply pavement preservation treatments is to follow the three 'Rs' – the right treatment on the right pavement at the right time.

The underlying concept behind pavement preservation application is illustrated in Figure 1. The key to an effective pavement preservation application is the optimal timing of application as well as choosing the right treatment. The schematic curve shown in Figure 1 illustrates that preventive maintenance should take place early in the pavement life. Pavement preservation options include spray applied treatments like fog seal, chip seal, slurry seal, and micro surfacing.

If the trigger condition is set too low, the preventive maintenance may be ineffective as they do not contribute any structural capacity to roadways. When a pavement reaches this condition, rehabilitation (such as mill and fill,

Cold in-Place Recycling [CIR], and Full Depth Reclamation [FDR]) or reconstruction are typically more cost-effective.

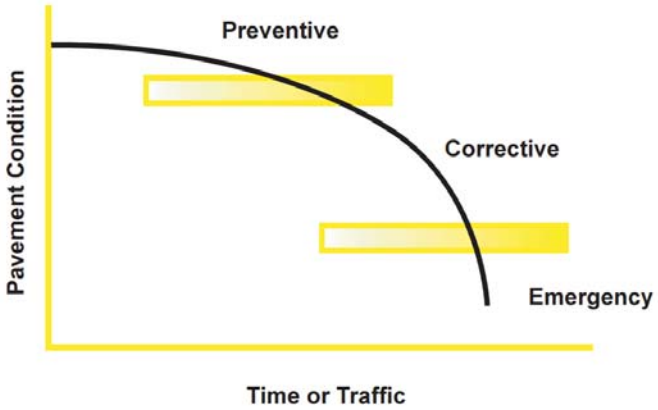

Figure 1. Concept of applying pavement preservation on pavement

In general, the purposes of pavement preservation surface treatments include sealing cracks (maintaining pavement), waterproofing surfaces (to protect undelaying pavements), increasing surface friction (safety), improving rideability, rejuvenating surfaces, and improving aesthetics. These treatments are also different in many ways, as they usually utilize different emulsion types and/or aggregate, and different methods of embedment. It cannot be overstated that application rate, timing, and construction quality are critical factors for surface treatment performance.

The treatment performance is usually measured by life cycle of the surface treatment itself, or by the life extension of the underlying pavement layers. Sometimes other factors, such as safety improvements, are also considered to measure a specific treatment performance.

Chip Seal

Chip seal is a type of seal coat and is the most common approach. A chip seal is an application of asphalt binder on existing pavement surface, followed by a placement of a layer of aggregate chips, and finally rolled to embed the aggregate into the binder. Chip seals provide a proper surface for light to high traffic roadways. It can create a waterproof, skid resistant surface, restore weathered surfaces, correct bleeding, provide a temporary base course cover, and define shoulders.

Chip seals can also be applied as double and triple layers, which are accomplished by applying additional layers of asphaltic material and aggregate. After applying each layer of aggregate, the surface is compacted using a roller to embed aggregates in the binder.

It should be noted that based on the literature review, a chip seal is not an appropriate method when the pavement is structurally deficient or cracks are generally wider than 0.25 inches. It is also not recommended where medium to high-severity alligator cracking, extensive potholes, and/or excessive rutting is present. Chip seals also include other limitations such as relatively long curing times for non-polymer modified emulsions, loose aggregate chips which can cause windshield damage, noise due to the rough surface, and need of warm weather to allow for construction.

Alternatives to chip seal include:

- Coal Tar
- Fog Seal
    - Bio Rejuvenator
    - Mastic
- Slurry Seal
- MicroSurface
- MicroMill

These chip seal alternatives are discussed in more detail.

Coal Tar

Coal Tar is created as a result of the "coking process" in steel manufacturing and is comprised of thousands of chemicals that are different in molecular structure than asphalt. Coal Tar Emulsion can protect the asphalt from the harsh effects of UV rays, petroleum-based products and water.

However, coal tar-based sealcoat materials are a potent source of polycyclic aromatic hydrocarbons (PAHs) to air, soils, streams, lakes, and homes. Due to potential risks to human health, coal tar usage is prohibited by many agencies today. Minnesota has recently passed a new law which bans the use and sale of coal tar-based sealcoats.

Fog Seal

Fog seal is a light application of diluted, slow-setting asphalt emulsion, rejuvenator or bio seal product without aggregate cover. When used, the pavement surface must be dry, clean, and in good condition. A critical factor for fog seals is the application rate of the liquid asphalt or rejuvenator, which should be in the range of 0.05 to 0.15 gal per square yard. Also, the roadway should not be opened to traffic until the surface is cured and adequate friction is restored. In general, a fog seal can be applied as light to moderate raveling and/or oxidation develop, but not when any structural distresses are present.

Fog seals can seal small cracks and surface voids, prevent raveling/popouts of chip seals or marginal aggregates used in hot mix asphalt (HMA), reduce snow plow damage, and darken new chip seals. However, there are concerns about loss of skid resistance of fog seal surfaces, especially during rain events.

A proper fog seal should be selected based on the project goal (sealing, rejuvenating, or aesthetics) and surface type (dense graded, open graded, or chip seal). Typical fog seal products differ greatly by curing time, impact on surface friction, application process and rates, costs and life cycle. These products include:

- CSS-1h, CSS-1 and SS-1h: Standard fog seal emulsions that meet state or AASHTO M-140 (anionic) and M-208 (cationic) specifications.
- CRS-2, CRS-2P, CRS-2Pd: CRS-2 is a cationic, rapid-setting emulsion that can be polymer modified (P for "polymer" modified) and/or diluted (d for "diluted"). The emulsion is diluted by the manufacturer with 3 parts of emulsion to 1 part water solution for a specified 51% asphalt residue content. CRS-2Pd is the only rapid-setting emulsion being used by MnDOT.
- Blacklidge LD-7: A specialized asphalt emulsion originally developed to be a fast-curing trackless tack coat. The hard residue can be used on dense graded HMA surfaces and it provides a black surface that is resistant to ultra-violet light degradation.
- Gilsonite Sealer Binders (GSB): Gilsonite based emulsions are marketed as a penetrating pavement maintenance tool.
- Grit or Mastic Surface Treatments:
    - Roads: Onyx®
    - Parking Lots, Trails : Axys®, TMat®, AsPen®

- Rejuvenator Emulsions: Rejuvenators differ greatly by curing time, effect on friction, ability to soften existing binder, tracking, dilution rates, and application rates and include:
    - Oils: ETR-1, ARA-1, Reclamite®
    - AC/Oil: Cyclogen®, ERA®
    - PMAC/Oil: Pass QB®

Bio Fog Seal

Bio fog seals have been introduced in the market in the last few years. The use of these emerging products may provide a sustainable alternative to traditional petroleum-based products and reduce negative environmental impacts. Common bio fog seal product include RePlay® and Anova™.

As bio fog seals are relatively new on the market, their benefits are not completely proven yet. The most commonly claimed benefit is their ability to prevent and reverse harmful oxidation factors to asphalt pavements (life extension). It is also commonly claimed that they penetrate effectively and cure in 15 to 30 minutes, which allows for minimal road closure time. In addition, some bio fog seals are clear and do not affect pavement markings, their application rates are often lower than traditional fog seal (as low as 0.02 per square yard), and are considered to be environmentally friendly.

Slurry Seal

Slurry Seal is a mixture of well-graded aggregate, slow-setting asphalt emulsion, fines, and additives. It can seal sound, oxidized pavements, restore surface texture by providing a skid-resistant wearing surface, improve waterproofing characteristics, correct raveling, and provide a new surface where weight restrictions preclude the use of heavier overlays. It is also a good application to use in subdivisions where curb exposure is an issue, as it usually helps maintain the minimum curb exposure requirements.

Slurry seals cannot be used to correct surface profile (micro surfacing should be used instead), fill potholes, or alleviate cracking and should be used primarily on good condition pavement.

Application rates for different aggregate types for slurry seals are shown in Table 1. The primary difference among the Type I, II, and III aggregates is the gradation and the aggregate top size. Type I slurries are the finest, Type II are coarser, and Type III have the coarsest grading. Typical nominal maximum aggregate size (NMAS) are No. 8 for Type I, No. 4 for Type II, and 3/8 inches for Type III slurry seals.

Table 1. Slurry seal rate of application

Aggregate Type	Location	Suggested Application Rate	Suggested Emulsion Application Rate*
Type I	Parking area, airport runways	8-12 lb/yd^2	10 – 16 %
Type II (most common)	General purpose, urban and residential streets, arterial routes, highways	12-20 lb/yd^2	7.5 – 13.5 %
Type III	High speed roads, industrial sites	18-30 lb/yd^2	6.5 – 12 %

*based on dry weight of aggregate recommended by the International Slurry Seal Association (Specification [3], Appendix A). The application rates can be different among various agencies and/or geographical zones.

Slurry seals do not produce loose chips, thereby eliminating the possibility of vehicle damage. In addition, slurry seals can also be placed within a wider temperature range require less testing, equipment and personnel, and allowable traffic speeds can be increased sooner in general. However, their inspection requirements, cure time, and performance attributes can be different among various agencies and/or geographical zones. Slurry seals are more expensive when compared to chip seals.

Micro surfacing

Micro surfacing is a thin, strong layer of asphalt emulsion and additives blended with finely crushed stone for friction characteristics. Micro surfacing also serves as a protective seal coat and can extend pavement life. Micro surfacing renews the road surface and seals minor cracks and other irregularities, inhibits raveling and surface oxidation, improves surface texture, and fills minor ruts and other surface irregularities. However, micro surfacing typically has a slightly higher cost than both slurry seals and chip seals as it utilizes a polymer-modified emulsion and other additives such as cement. Micro surfacing is more common for roadway applications because of better performance and the enhanced benefits previously discussed. Table 2 presents a comparison of all preservation methods discussed so far. Table 3 provides market products including the areas and producers.

Table 2. Preservation method comparison

Method	Cost ($/yd^2)	Typical Treatment Life (Years) Based on Pavement Condition		
		Good	Fair	Poor
Micro surfacing	2.5 – 3.5	12 – 15	7 – 12	5 – 7
Chip Seal	0.8 – 1.5	6 – 8	4 – 6	3 – 4
Slurry Seal	1.3 – 2.2	6 – 7	Limited use/performance	Not recommended
Fog Seal	0.3 – 1.5	1 – 3	Limited use/performance	Not recommended
Bio Fog Seal	1.0 – 1.6	3 – 5*	Limited use/performance	Not recommended

*based on the Paper [19], Appendix A.

Table 3. Market products

Company	Product	Area	Website
Valley Slurry Seal Co.	---	Slurry seal	http://www.slurry.com/
Astech	---	Slurry/Micro seal	Asphalt Surface Technologies Corp. a/k/a Astech Corp. St. Cloud (320) 363-8500
Biorestor	Biorestor	Agricultural Based Asphalt Seal and Rejuvenator	http://www.biosealusa.com/
Pavement Technology, Inc	Reclamite	Asphalt rejuvenator	http://pavetechinc.com/
Zydex	ZycoTherm	Asphalt additive	http://www.zydexindustries.com/default.aspx
Seal Master	AsPen	Asphalt rejuvenator	http://sealmaster.net/
Prevent Potholes	FASTSET	Polymer Modified Cationic Asphalt Emulsion Fog Seal	http://www.preventpotholes.com/
Bio Pave Products LLC	RePlay®	Agricultural Oil Seal and Preservation Agent	http://www.valleysealcoat.com/replay.php
Gee Asphalt Systems Inc.	GSB-88	Asphalt Cement Rejuvenator	http://www.geeasphalt.com/
Cargill	Anova™	Bio-based rejuvenators and emulsifiers	http://www.cargill.com/products/industrial/asphalt-solutions/index.jsp
Invia/Ingevity	Onyx Axys	Mastic Seal	https://www.invia-tech.com/

Survey

Braun Intertec has gathered information from Midwest agencies, contractors, and material suppliers via phone and in person interviews. Interview process had the following steps:

- A list of suggested states/agencies, contractors and suppliers was prepared. A primary contact in each organization was identified.
- Primary contacts were contacted accordingly to see if they are willing to be interviewed.
- Phone interviews were conducted following the standard questionnaires prepared for agencies and contractors.
- Once the interviews were done, the interview transcripts were prepared and sent to the interviewees for their review to insure the messages provided in the TRS reflect their approaches and opinions.

Interviewees were as follows:

- Dale Strandberg, Astech Construction
- Trevor Christianson, Mayo Construction North Dakota
- Larry Galehouse, National Center for Pavement Preservation
- Willy Schacher, North Dakota DOT, Fargo District Maintenance
- Bob Rea, Nebraska DOT
- Gill Hedman, South Dakota DOT
- Dale Heglund, Upper Great Plains Transportation Institute
- Todd Weist, Tri- State Asphalt, Morris Illinois
- Tara Liske, Province of Manitoba Canada
- LaDonna Rowden, Illinois DOT
- Al Johnson, WisDOT Maintenance

Standard questionnaires were developed for both the agencies and contractors as follows:

Questions for the Agencies

- What pavement preservation method(s) do you use?
    - Properties
    - Cost
    - Typical life cycle (application frequency)
- How do you check the construction quality?
- What kind of inspection tests do you run?
- What are your expectations from the contractor?
- How do you measure performance?
- How do you select a strategy?
- What can be done to make the preservation last longer?
- Any challenging project you want to talk about? Describe the nature of the problems and the way you overcame them.

Questions for the Contractors

- What pavement preservation method(s) are you using?
    - Properties
    - Cost
    - Typical life cycle (application frequency)
- Which method(s) do you prefer? Why?
- What are the construction issues?
- What can be done to make the preservation last longer?
- What can be done to help improve quality?
- What is your best alternative(s) to Chip Seal?
- Any challenging project you want to talk about? Describe the nature of the problems and the way you overcame them.

According to the survey, five main pavement preservation methods that are widely used in the Midwest are: fog seal, chip seal (most common method), slurry seal, micro surfacing, and thin lift overlays. The cost depends on many factors like the amount of work, material used, project location, etc., but generally speaking, the cost per square yard follows the same trend (lowest for the fog seal and highest for the thin lift overlays). Typical life cycle has the same trend too, with 1-3 years for fog seal and more than 10 years for the thin lift overlays.

Also, up front pavement evaluation to capture the true condition of the roadway pavement is believed to be a necessary component in order to utilize the most suitable strategy for a given roadway. The initial pavement condition evaluation, along with a detailed quality control (QC) program and full time inspection during construction, can assure a high quality long-lasting surface treatment.

Transcripts of the surveys are included in Appendix B.

Summary

This TRS summarizes the current State of the Practice of surface treatment alternatives to chip seals used in the Midwest and establishes a list of products and techniques for Minnesota cities and counties. The findings from this literature review and survey results are as follows:

- The proverb commonly cited to effectively apply pavement preservation treatments is to follow the three 'Rs' – the right treatment on the right pavement at the right time.

- Surface treatment purposes include sealing cracks (maintaining pavement), waterproofing surfaces (to protect underlying pavements, improving friction (safety), improving rideability, rejuvenating surfaces, and aesthetics. These treatments are also different in many ways, as they usually utilize different emulsion types and/or aggregate, and different methods of embedment.

- The obvious benefits of surface treatments include; slowed aging process, waterproofed surfaces, prevention of stone loss, increased surface friction, and better surface appearance.

- Timing of the application of any surface treatment is crucial for optimum performance. When proper preservations are delayed for a variety of reasons the benefits are significantly reduced and in some cases completely lost. Sticking with the plan is necessary for success.

- Chip seals are by far the most common surface treatment used and preferred by most agencies in the Midwest.

- Fog seals have been used to assure performance of an HMA overlay having marginal aggregates and are applied right after or shortly after the HMA has been placed.

- Micro surfacing is usually preferred over slurry seal, as it utilizes a polymer modified binder. There is also little difference in cost between slurry and micro surfacing in many cases.

- Aside from the road surface condition, the biggest construction issue appears to be dealing with the traffic during the construction. Also, using less common material such as asphalt binders and cutbacks for chip seals should be done with care. Residual asphalt is typically greater for these materials and thus normal application rates (used with more common emulsions) will need to be adjusted accordingly.

- Premature surface treatment failure can happen if the proper treatment and material is not selected for the specific project. Educating agency's personnel is very important. Sometimes the premature failure happens because the material being placed has too low binder content.

- From the contractor's point of view, best alternatives to chip seal include micro surfacing, cape seal (a chip seal followed by a micro surfacing), and sand seal followed by a sand surface covering.

- Micro surfacing and cape seal perform the best at resisting turning movements, followed by slurry seal and chip seal. There are concerns about loss of skid resistance of fog seal surfaces, especially during rain events.

- The main tool for the agencies to check the construction quality is having contractors to provide detailed quality control (QC) programs to accurately follow specifications and guidelines on the application rates and material sampling (aggregate and emulsion) throughout the project.

- No specific performance tests have been developed to measure performance of surface treatments.

- From the agency's point of view, contractors who take quality control seriously provide a good-performing, long-lasting treatment most of the time.

- Most contractors and suppliers would like to be involved in the decision process for strategy selection and specification development.

- Agencies tend to select strategies mainly based on past experience on similar projects. It would be very beneficial if guidelines and standards for selecting the proper treatment were adopted and applied uniformly. A summary of the key properties of the available seal coat alternatives are shown in Table 4.

Table 4. Seal coat alternatives summary

Method	Key Notes
Micro surfacing	✓ Works well in areas with excessive turning movements ✓ Does not require cover aggregate (no loose chips) ✓ Resistant to scraping or abrasion from carbide snow plow blades ✓ Can correct the surface profile to some degree (fills minor ruts and other surface irregularities)
Slurry Seal	✓ Works okay in areas with excessive turning movements ✓ Does not require cover aggregate (no loose chips) ✓ Resistant to scraping or abrasion from carbide snow plow blades
Chip Seal	✓ The most common approach ✓ Can restore or improve skid resistance ✓ Vehicle damage from flying stones (loose chips)
Fog Seal (and Bio Fog Seal)	✓ Can minimize impacts to the traveling public and adjacent homeowners in urban areas ✓ Is spray applied ✓ Reduces scraping or abrasion from carbide snow plow blades ✓ Loss of skid resistance, especially during rain events

Appendix A – Literature Review

Literature Review Resources

Papers and Reports

[1] Yang X., You Z., Dai Q., and Mills-Beale J. (2014) "Mechanical Performance of Asphalt Mixtures modified by bio-oils derived from waste wood resources," Construction and Building Materials, Volume 51, pp. 424–431.

From the conclusion: The addition of bio-oil can improve the fatigue performances of asphalt mixtures significantly. The addition of bio-oil has slightly negative effect on the indirect tensile strength and rutting performance of the asphalt mixtures, but the effect on rutting performance is not statistically significant. Overall, bio-oils generated from waste wood resources can be a good extender and modifier for the petroleum asphalt binders when low bio-oil fraction is used, as described in this paper where the bio-oils are at less than 10% by weight of asphalt binder.

[2] Qureshi N.A., Tran N.H., Watson D., and Jamil S.M. (2013) "Effects of Rejuvenator Seal and Fog Seal on Performance of Open-Graded Friction Course Pavement," Maejo International Journal of Science and Technology, Volume 7, No. 2, 2013, pp. 189-202.

From the conclusion: Fog and rejuvenator seals significantly affect the micro and macro texture of the OGFC surfaces in general. The surface friction may be reduced up to 24 percent depending on the type of modified binder used in the pavement, the type of rejuvenator or fog seal material, and the application rate. Therefore, fog and rejuvenator seals should be used with caution on OGFC as they may cause a temporary loss of friction. A trend of reduced air voids was observed with increase in rejuvenator/fog seal application rates, which is a matter of concern as the functionality of OGFC mix would be affected. The rejuvenator seals appear to improve the abrasion resistance.

[3] Lee J. and Kim Y.R. (2006) "Performance Evaluation of Asphalt Surface Treatments Using MMLS3," Airfield and Highway Pavements, pp. 86-97.

From the conclusion: The results from the Model Mobile Loading Simulator (MMLS3) aggregate retention test confirm that the amount of aggregate loss decreases as the aggregate application rate decreases, the emulsion application rate increases, the fine content decreases, and the gradation becomes more uniform. The amount of fine has much less an effect on aggregate loss in the light weight asphalt surface treatments with a more uniform gradation than it has on aggregate loss in the granite asphalt surface treatments with a less uniform gradation.

[4] Im J.H. and Kim Y.R. (2013) "Development of Fog Seal Field Test Methods and Performance Evaluation Using Polymer-Modified Emulsions," Transportation Research Record: Journal of Transportation Research Board.

From the conclusion: At high temperatures and low Emulsion Application Rates (EARs), emulsions cure quickly, but low EARs can lead to poor pavement surface performance. Overall, Polymer Modified Emulsions (PMEs) show more effective emulsion curing rates than unmodified emulsions. Two relationships are found between the bond strength and field tests, i.e., the damping test and the rolling ball test, respectively, which reveal the same or similar bitumen bond strength limits for identical emulsion types and EARs. High EARs correlate to more bleeding areas for all the study emulsion types.

[5] Hajj E. Y., Loria L. G., Sebaaly P. E., Borrel C. M., and Leiva P. (2011) "Optimum Time for Application of Slurry Seal to Asphalt Concrete Pavements," Transportation Research Record: Journal of the Transportation Research Board, Volume 2235, pp. 66–81.

From the conclusion: Asphalt pavements should be allowed to cure for the first three years prior to the application of any surface treatment. This is shown by the low benefits of applying slurry seal immediately after and one year after construction. A 3-year curing period of asphalt pavements will allow the asphalt mix to gain strength and built-up its resistance to early rutting and shoving. This is shown by the noticeable upward shifting of the performance curve for the pavements that received slurry seals three years after construction. The application of surface treatments on asphalt pavements three years after its construction will protect the asphalt mix from excessive aging and improves its resistance to cracking, e.g. fatigue, thermal and block. This is shown by the noticeable upward shifting of the performance curve for the pavements that received slurry seals three years after construction and the extension of the pavement life at the terminal PCI level of 40.

[6] Hajj E. Y., Loria L. G., Sebaaly P. E., Cortez E., and Gibson S. (2013) "Effective Timing for Two Sequential Applications of Slurry Seal on Asphalt Pavement," Journal of Transportation Engineering, Volume 139(5), pp. 476–484.

From the conclusion: The application of the first slurry seal immediately after or 1 year after construction of the asphalt layer is not effective in terms of both the benefit to the users and the cost-benefit ratio for the agency. Regardless of construction activity, optimum time for a sequential slurry seal is when the first slurry seal is applied in year 3 and the second slurry seal is applied in year 7. Consequently, on the basis of the developed performance models, the optimum time for sequential slurry seals of newly constructed pavement is when the first slurry seal is applied at PCI of 90 and the second slurry seal is applied at PCI of 86. However, the optimum time for sequential slurry seals of overlaid pavement is when the first slurry seal is applied at PCI of 87 and the second slurry seal is applied at PCI of 77. The pavement service life was extended by 2.0 to nearly 4.0 years when the slurry seals were applied at optimum time. For such application conditions, the sequential slurry seal was effective in delaying the time until reconstruction.

[7] Asli H., Ahmadinia E., Zargar M., and Karim M. R. (2012) "Investigation on Physical Properties of Waste Cooking Oil – Rejuvenated Bitumen Binder," Construction and Building Materials, Volume 37, pp. 398-405.

From the conclusion: The ANOVA evaluation confirms that there is no significant difference between the rejuvenated bitumen and the original bitumen. The penetration value shows that there is a significant difference between the rejuvenated bitumen (the aged bitumen pen-grade 50/60 with 1% waste cooking oil content) and the original bitumen. This means that less than 1% added waste cooking oil into the aged bitumen may resemble the original bitumen. However, the softening point test and the Brookfield viscosity test indicate that there are no statistically significant differences between the rejuvenated bitumen and the original bitumen. The results show the ability and potential of a rejuvenator, such as waste cooking oil, for recycling bituminous pavement in order to decrease the maintenance cost of the existing asphalt pavement.

[8] Lin J., Gue P., Wan L., and Wu S. (2012) "Laboratory Investigation of Rejuvenator Seal Materials on Performances of Asphalt Mixtures," Construction and Building Materials, Volume 37, pp. 41-45.

From the conclusion: The three types of Rejuvenator Seal Material (RSM) decrease the complex modulus and increase the phase angle of aged asphalt binder, and also decrease the rutting parameter of aged asphalt binder. The RSM significantly increase the rutting depth of HMA. Moreover, the RSM treated HMA show lower ITS and higher creep strain as compared with untreated HMA. The RSM decrease the rutting resistance of HMA. The RSM can effectively decrease the raveling of HMA subjected to freeze–thaw cycles and immersed in petrol–diesel solution, which is meaningful for the asphalt pavement with heavy traffic. The skidding resistance of HMA is definitively decreased by RSM, and the skidding resistance tests must be performed prior to field applications of RSM.

[9] Lin J., Hon J., Huang C., Liu J, and Wu S. (2014) "Effectiveness of Rejuvenator Seal Materials on Performance of Asphalt Pavement," Construction and Building Materials, Volume 55, pp. 63-68.

From the conclusion: The effective penetration depth of Rejuvenator Seal Material (RSM) on HMA is proposed and determined by complex modulus changes of extracted asphalt binder from different regions in vertical position in HMA. The effective penetration depth of RSM L and J is 10–20 mm in HMA. The effective penetration depth of RSM cannot be determined by characteristic absorption peak of FTIR spectrum for extracted asphalt binder. However, the carbonyl area index calculated from FTIR spectrum of extracted asphalt binder is consistent with the complex modulus changes. Therefore, the carbonyl area index can be also used to illustrate the effective penetration depth of RSM. The effectiveness of RSM on HMA can be depicted by variation of predicted ductility extracted asphalt binder, and the use of RSM can increase the ductility of asphalt binder in HMA from regions in the certain depth, which will help to decrease the potential of ductile related cracking in HMA.

[10] Chiu C. and Lee M. (2006) "Effectiveness of Seal Rejuvenators for Bituminous Pavement Surfaces," Journal of Testing and Evaluation, Volume 34, No. 5.

From the conclusion: The three rejuvenators, one cutback asphalt and two emulsions, one tar based and the other asphalt based, appeared to penetrate into the pavement to a depth of no more than 2 cm, even though the average air void content of the pavement was as high as 9.7%. All three rejuvenators showed a considerable softening effect on the old asphalt binders in the top 1 cm of the treated pavement. The cutback rejuvenator showed the greatest softening effect, giving a 90% reduction in viscosity at 60°C in the recovered asphalt binder. The tar based emulsion gave a reduction of around 75%, while the asphalt-based emulsion gave a reduction of around 45%. The two emulsion type rejuvenator could dry within two hours after application, while the cutback type took about seven hours to dry. The application of these rejuvenators caused a reduction in pavement surface friction (about 20% reduction in British Pendulum Number(BPN)) and in pavement surface texture (about 10 % reduction in Macro Texture Depth(MTD)). For those pavement sections with low MTD but high design speed, the reductions of friction might not be acceptable.

[11] Zubeck H, Liu J., and Mullin A. (2012) "Pavement Preservation Practices in Cold Regions," Alaska Department of Transportation.
Link: http://tundra.ine.uaf.edu/wp-content/uploads/2013/05/Pavement-Preservation-Practices-in-Cold-Regions-12-05-12.pdf

From the conclusion: Pavement preservation treatments, Crack Sealing, Patching, Fog Seals, Chip Seals, Slurry Seals, Asphalt Surface Treatment (AST)/Bituminous Surface Treatment (BST), Micro surfacing, Thin Overlays, Bonded Wearing Courses, Interlayers and In-place Recycling, are used in cold regions and have potential for use in Alaska. Crack sealing and patching are the most extensively used pavement preservation techniques and their use in Alaska should be continued. Use of chip seals, fog seals, slurry seals should be considered job specifically. Construction is limited to temperatures > 60°F, which creates a problem for many Alaskan locations. These treatments are not used in other cold regions with heavy studded tire usage. The service life of the treatments varies from about 3 years to 12 years. The literature and the survey agree that micro surfacing and thin overlays have the longest service life. Most regions use several performance measures to determine trigger values for the due time of pavement preservation treatments. IRI, rutting, cracking and expert opinion are used extensively. The costs of treatments vary from a region to another as well as from project to another. Other issues than cost effectiveness can be considered when marketing pavement preservation; these issues include sustainability, green products and technologies and traffic safety.

[12] Shober S.F. and Friedrichs D.A. "A Pavement Preservation Strategy," Wisconsin Department of Transportation.
Link: http://wisdotresearchtest.engr.wisc.edu/wp-content/uploads/pavpreserv.pdf

From the conclusion: The pavement evaluation process presented here provides a logical approach to progressing from field observations of distress to proposed treatment strategy. Measurements of ride, rut and distress

(Pavement Distress Index (PDI)) are compared to thresholds established for each of these measurements. When one or more thresholds for a pavement section are crossed, the need for treatment is established. Specific pavement distresses are used to define specific pavement problems. Field measurements (observations) of the severity and extent of specific pavement distresses are used to define pavement distress levels. Matrices of pavement distress levels are used to define pavement problem levels. Each identified pavement problem (and its associated problem level) is compared to the list of all possible treatments for that pavement type. Each treatment is classified as unacceptable (not appropriate for the problem), preferred (a treatment appropriate to the level of the problem), or excessive (a treatment which is more than necessary). Finally, treatment levels identified as "Low Cost", "Best Value", and "Longest Life" are established based on manipulation of cost and expected life data for each treatment on the short list of viable options.

[13] Anderson R. M. (2014) “Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in Hot-Mix Asphalt Pavements,” Minnesota Department of Transportation.
Link: http://www.dot.state.mn.us/research/TS/2014/201445.pdf

From the conclusion: In the MnROAD Cell 24 and TH 56 test sections, aging of the asphalt pavement, as measured using several asphalt binder properties, was shown to be significantly higher near the surface (within the top 12.5 millimeters) than further down in the pavement structure. The aging that was expected to occur as the time is extended from construction to sealing was not readily seen in the asphalt binder properties of the Cell 24 subsections. The aging that was expected to occur with time was observed by a change in the asphalt binder properties of the bottom layers of the Cell 24 subsections. Contrary to expectations and initial data analysis all of the subsections, including the Control, exhibited no discernible trend indicating that time from construction to sealing had a significant effect on asphalt binder properties. With only five years of service from construction to the last coring, more aging may be needed to see any significant effects. The analysis of the fracture energy of the cores from TH 56 indicates that waiting more than two years after construction to place a chip seal could result in fracture properties that would ultimately be the same as if the pavement were not sealed at all. This is not to suggest that other benefits could not be realized by a later chip seal, but rather that the aging that impacts the fracture properties can be mitigated by sealing earlier.

[14] Wilde W. J. (2014) “Cost-Effective Pavement Preservation Solutions for the Real World,” Minnesota Department of Transportation.
Link: http://www.dot.state.mn.us/research/TS/2014/201433.pdf

From the abstract: The primary objective of this project is the development of a set of guidelines, or best-practices, and a source of information for further study in the topics of pavement preservation, pavement management, construction, and other areas. The main deliverable of the project is an interactive document intended to serve as a reference manual for those with responsibilities in this area. Thus, the document is made up of sections or modules, which can be accessed individually or read sequentially throughout the document. The interactive document produced as a result of this project is not intended to provide specific answers or strategies for highway and street agencies when developing plans for pavement preservation. It does, however provide the user with the appropriate background and sources of information with which to develop a pavement preservation program with associated activities, timing, and prioritization.

[15] Wood T., Pantelis J., Watson M., and Olson R. C. (2014) “Preventative Maintenance for Recreational Trails,” Minnesota Department of Transportation.
Link: http://www.lrrb.org/media/reports/200925.pdf

From the conclusion: Fog sealing of a recreational trail in good condition can extend the pavement life and provide a quality surface for trail users. Some considerations need to be addressed such as pavement age, location, surface condition and current distress of pavement to receive treatments. Adding preventive maintenance activities at an earlier pavement life can extend the serviceable life of a trail. It has been demonstrated that starting preventive maintenance treatments at time of construction and continuing them on a regular base has slowed or stopped the aging of these trails. For older trails which are pocked and porous, the CRS-2pd (diluted polymer

modified cationic rapid-setting emulsion) may be the best choice to seal and fill the surface caused by the lost fine aggregate and asphalt binder during aging of the bituminous. Not applying preventive maintenance techniques to recreational trail networks can result in unsatisfied users and costly corrective maintenance and increased reactive maintenance or earlier reconstruction.

[16] Smith K. L., Titus-Glover L., Darter M. I., Von Quintus H. L., Stubstad R. N., and Hallin J. P. (2005) "Evaluation of the Cost Benefits of Continuous Pavement Preservation Design Strategies versus Reconstruction," Arizona Department of Transportation, Final Report 491.
Link: http://ntl.bts.gov/lib/25000/25000/25015/AZ491.pdf

From the recommendations: Pavement survival analyses should be routinely (perhaps biennially) performed to develop more complete and accurate estimates of initial pavement life and rehabilitation performance. Specifically, an improved database with few errors is greatly needed for all pavements of interest and better forecasting is needed for a variety of designs/materials: SuperPave mixes, doweled jointed concrete (JPCD) pavements (the current Arizona design), concrete pavement rehabilitation treatments, and asphalt pavement rehabilitation treatments utilizing different asphalt mixtures. A comprehensive economic analysis, using reasonably accurate estimates of pavement life and traffic loadings, should be performed for all major pavement projects to determine not only the type of pavement to use, but the optimal timing of reconstruction. For most of the conditions prevailing in Arizona, a reasonable estimate of the optimal timing for reconstruction is after the sequential application of two to three rehabilitation activities. User costs stemming from the time delay associated with work zones should be evaluated as part of the pavement Life Cycle Cost Analysis (LCCA). The evaluation of vehicle operating costs resulting from decreased pavement smoothness should be considered in pavement LCCA. Moreover, the use of cost adjustment factors, such as those used by the Minnesota DOT, should be considered, particularly for pavements maintained at a lower serviceability level.

[17] Gransberg D. and James D. M. B. (2005) "Chip Seal Best Practices," NCHRP Synthesis 342.
Link: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_342.pdf

From the conclusion: Maintenance chip seals can play an important role in the nation's pavement preservation program. Therefore, they deserve the same level of technical engineering rigor that is reserved for the hot-mix asphalt pavements whose design life the chip seals extend. Five of the U.S. states that responded to this study's survey reported that they do not use maintenance chip seals. This is an indication that the value placed on chip seals by the states reporting excellent results from their programs is not shared across the nation. Some states rate their chip seal experiences as "unacceptable," whereas neighboring states may rate their experiences as "good." Such differences in practice are difficult to explain. This study has found that maintenance chip seal practices can be instituted that will improve the reliability of maintenance chip seals. Many of the best practices identified fell in the areas of construction procedures and equipment management practice. This is not surprising, in that construction is the most critical portion of the chip seal project life cycle.

[18] Cline G. D. (2011), Evaluation of a Corrosion Control Material for Asphalt Reservation of DOD Airfield Pavements," Naval Facilities Engineering Command (NFEC), Technical Report TR-2363-SHR.
Link: http://roadsandconcrete.com/wp-content/uploads/2015/08/Review-GSB-88-DOD-Evaluation.pdf

From the conclusion: Department of Defense (DoD) and Federal Government Regulations' as well as Navy (and other services) various instructions, policies, etc., have discouraged asphalt pavement preservation via sealants for numerous reasons, including the technical issues of friction and FOD generation NAVFAC ESC recommends reasonable changes in budget and policy that would allow for the use of asphalt preservation methods and materials. Based on the results of this evaluation it appears that requiring facilities to apply proven materials to all asphalt while the pavement is still in good condition (PCI > 60) would increase readiness and reduce life cycle costs. When selecting any preventative maintenance procedure the responsible airfield activity shall measure the resulting friction coefficient to verify that the resulting surface meets the operational criteria before resuming operations.

[19] Shatnawi S. (2014), "A White Paper on: RePlay® Agricultural and Preservation Agent," Shatec Engineering Consultants, Eldorado Hills, California.
Link: http://midstatesequipment.net/Documents/RePLAY/Replay%20WP%2010-6-14%20FINAL.pdf

From the conclusion: When used in preventive maintenance mode, RePlay® can add five years to the service life with each application. Besides, unlike petroleum-based products, it is nontoxic, non-polluting, safe for both the users and construction workers, environmentally friendly, and not affected by increasing the price in oil.

[20] Montana Department of Transportation Research Programs (2015), Evaluation of Various Bituminous Concrete Pavement Surface Treatment, Experimental Projects Program.
Link: http://www.mdt.mt.gov/other/webdata/external/research/docs/epsl/fmc/EVAL_JUN15.pdf

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Link: http://www.idot.illinois.gov/assets/uploads/files/doing-business/manuals-split/design-and-environment/bde-manual/Chapter%2052%20Pavement%20Preservation.pdf

[2] International Slurry Surfacing Association (2010), Recommended Performance Guideline for Micro Surfacing, ISSA A143.
Link: https://www.mdt.mt.gov/publications/docs/brochures/research/toolbox/ISSA/a143.pdf

[3] International Slurry Surfacing Association (2001), Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal, ISSA A105.
Link: https://www.mdt.mt.gov/publications/docs/brochures/research/toolbox/ISSA/a105.pdf

[4] Nebraska Department of Roads (2002), Pavement Maintenance Manual.
Link: http://www.transportation.nebraska.gov/docs/pavement.pdf

[5] Federation of Canadian Municipalities and National Research Council (2005), Preservation of Bituminous Pavement Using Thin Surface Restoration Techniques.
Link:
https://www.fcm.ca/Documents/reports/Infraguide/Preservation_of_Bituminous_Pavement_Using_Thin_Surface_Restoration_Techniques_EN.pdf

[6] South Dakota Department of Transportation (2010), Pavement Preservation Guidelines.
Link: http://sddot.com/resources/manuals/PavementPreservationGuidelines1112011.pdf

[7] Texas Department of Transportation (2010), Seal Coat and Surface Treatment Manual.
Link: http://onlinemanuals.txdot.gov/txdotmanuals/scm/scm.pdf

[8] Virginia Department of Transportation (2010), Slurry Surfacing Certification Study Guide.
Link: http://www.virginiadot.org/VDOT/Business/asset_upload_file259_3529.pdf

[9] Wisconsin Department of Transportation (2015), Surface Treatments and Pavements, Construction Manual, Chapter 5.
Link: http://www.wsdot.wa.gov/publications/manuals/fulltext/M41-01/Chapter5.pdf

[10] Manitoba Infrastructure and Transportation (2012), Manitoba Surface Condition Rating Manual.

Appendix B – Surveys

Interview # 1: Dale Strandberg, Astech Construction

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Astech provides: (Crack Seal), Fogseal, Chip seal, Slurry Seal and Micro surfacing. The properties of each relate to the type of distress and/or Agency expectation they are addressing. The cost depends on many factors like amount of work, materials used, location of project etc. but relatively speaking the cost per yd2 is lowest to highest as listed below with the typical lifecycle of each application:

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	1 to 2 years
Chip Seal	7 years
Slurry Seal	7 years
Micro surfacing	7 years

It was interesting that Dale applied the same lifecycle for the surface treatments other than Fogseal. He said the properties and application of the various surface treatments for the distress condition of the road is key to selection. Choosing the lowest cost surface treatment and applying it to a road that has distress beyond the capabilities of the surface treatment applied leads to trouble. He also mentioned that they use commodity fog seals, at times conduct double chip seals and have been involved with new Micro milling applications.

2. *Which method do you prefer? Why?*

Dale said the method doesn't matter to him but the method (application) should fit the surface distress and roadway condition they are applied on. He also mentioned that he would like to be more involved in the decision for selecting a proper treatment to help assure a successful outcome.

3. *What are the construction issues?*

In the past, the road surface condition and weather were the primary construction issues they faced. Now, their biggest issue is dealing with traffic during the application. He said materials used are typically not an issue as long as they meet the specifications.

4. *What can be done to make the preservation last longer?*

The three things Dale said could be done are: 1) Use the best available materials, 2) Find the correct application and apply that correctly, and 3) Make sure there is enough binder to assure the proper fix.

He went on to say premature failures for surface treatments and the underlying pavements often stem from having too low of a binder content in the material being placed.

5. *What can be done to help improve quality?*

If cost is not an issue, then new Micromill technology should be used to assure the proper surface condition prior to applying the surface treatment. This will result in a smoother ride which in turn allows for a longer lasting treatment and improved performance of the overall pavement structure.

6. *What is your best alternative to chip seal?*

A sand seal which would be a CSS-1h emulsion followed by a sand surface covering. Without the sand, the surface would be too slippery and unsafe.

7. *Any challenging project you want to discuss?*

No.

Interview #2: Trevor Christianson, Mayo Construction North Dakota

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Mayo provides: Fogseal (when required on new HMA projects in the Grand Forks District), Slurry, Micro surfacing and Thin lift overlays (< 1.5"). The cost of each depends on many factors like amount of work, materials used, location of project, etc. but relatively speaking the cost per yd2 is approximately as listed below with the typical lifecycle of each application:

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	Used on new overlays only – see Will Schacher's interview
Slurry Seal ($2.75/yd2)	5 years
Micro surfacing ($3 – 3.50 /yd2)	5 -7 years
Thin lift overlays ($60k per lane mile)	7 – 10 years

Trevor said there is very little difference in cost between slurry and micro surfacing. The main cost difference is Micro surfacing utilizes a polymer modified binder and a slurry does not. The range for micro surfacing cost relates to whether or not there are multiple passes (scratch or rut fill followed by wear). Trevor also mentioned that the NDDOT has purchased a couple of Mini Mac machines which are primarily used to fill cupped transverse cracks to provide a smoother ride and extend pavement life between fixes.

2. *Which method do you prefer? Why?*

Trevor said the best method depends on the roadway condition on which they are applied. He said each method has their place based on the distress they are addressing and the desired outcome of the treatment. He said more than half of the thin lift overlays are RAP mixes where the surface of the road is milled and those millings are reincorporated back into the thin lift overlay HMA. Up to 25% RAP is allowed in the HMA per NDDOT specification.

3. *What are the construction issues?*

For thin lift overlays you need sufficient roadway width for the added thickness. Also, because of limited aggregate resources, haul distances have increased dramatically (20 miles to 50 miles). Almost all projects now utilize SuperPave mix which requires more rock than mixes from the past.

For micro surfacing the biggest issue is trying to apply it on roads that are not sound. Micro is not a fix and must be applied on a sound road. The micro surfacing process is also moving more toward urban locations which requires more compact equipment and more careful operations.

For slurry seals, Trevor feels that because of the low cost differential, there are very few instances where slurry seals should be applied. The superior performance of micro surfacing more than justifies the small increase in cost.

4. *What can be done to make the preservation last longer?*

Do a better job preparing for the surface treatment. Sometimes the proper surface treatment is not utilized because not enough pavement evaluation work is done up front. Up front pavement evaluations need to capture the true condition of the pavement – things you cannot see with the naked eye. Also, develop a long term plan and stick to it. Do not extend the preservation repair cycle beyond the original plan because of budget constraints.

5. *What can be done to help improve quality?*

Eliminate disconnect between the agency designer and the Industry. Have Industry more involved in the front end decisions along with conducting better pavement evaluations as previously mentioned. Also, growth in pavement preservation in N. Dakota has resulted in a lack of experience, knowledge and understanding of pavement issues, causes and how things are done in the state. New entrants in the market and/or Agency inexperience can cause project failures that set the entire process back. Adequate field experience and process capabilities must be assured before a project is awarded and administered.

6. *What is your best alternative to chip seal?*

Micro surfacing is the best alternative. A change from a PG 58-28 to PG 64-28 has provided viable alternatives for thin lift overlays.

7. *Any challenging project you want to discuss?*

Centerline rumble strips are creating pavement distress immediately and adding additional challenges to future surface treatment projects on the roadway (must be properly filled prior to surfacing, then reestablished).

Interview #3: Larry Galehouse, National Center for Pavement Preservation

(Larry travels the entire country working closely with Agencies and Industry to advance Pavement Preservation concepts and assist in implementation. His commentary is based on a vast experience with rejuvenators, fog seals, chip seals, scrub seals, slurry seals, micro surfacing and thin HMA overlays.)

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Rejuvenators are gaining greater use across the country. Most asphalt binders have fewer high end volatiles due to efficiencies in the refining process than just a few years ago. Because these high-end fractions can play a key role in retarding the aging process, preservation surface treatments have, and will continue to have, a huge role in any long-term pavement strategy. Larry found that many local agencies in Ohio determined that the application of rejuvenators with maltene fractions on today's asphalt pavements provided substantial benefit when applied early in a pavement's life. Agencies must be willing to tolerate an initial loss of friction for a short period of time. Contract cost is $0.80 to $0.95 per square yard. Life extension can range from 3 to 5 years if applied early in the pavement life.

Fog seals may or may not have some rejuvenating properties. In most cases, the fog seal is a diluted asphalt emulsion that fills the surface voids in the pavement, thus slowing oxidation and protecting the pavement structure from water infiltration. Although visually, the fog seal seems to disappear within a short period, the benefits remain much longer. Agencies must be willing to tolerate an initial loss of friction, present for a short period of time. Contract cost is $0.25 to $0.45 per square yard. Life extension can range from 2 to 3 years if applied early in the pavement life.

Scrub seals are a process by which a membrane of modified asphalt binder is scrubbed by a squeegee or a series of brooms into cracked and aged surfaces. The resulting surface is generally sanded and then covered with a slurry or chip seal. This process helps to prevent cracks from reflecting through the surface treatment for a longer period of time. Contract cost is $0.40 to $0.55 per square yard. Life extension from this pre-treatment can range from 2 to 4 years of additional pavement life.

Chip seals are the most commonly used treatment in the world. Proper construction requires attention to detail and the use of suitable and uniform sized aggregate. Montana and Wyoming routinely place chip seals immediately (same year) after constructing their overlays and are getting longer lasting and better performing pavements. Contract cost is $1.50 to $2.50 per square yard. If properly constructed a chip seal can typically extend the pavement life from 5 to 7 years.

Slurry seals are typically used on lower volume roads or streets with a good cross-section. It is a monolayer treatment, meaning it is one stone in thickness. The slurry seal set time before opening to traffic depends on the atmospheric conditions. Contract cost is $1.75 to $2.50 per square yard. Life extension can range from 4 to 5 years depending on pavement suitability.

Micro surfacing can be used on any facility, including high-volume roadways. The product is ideal for rut-filling and correcting minor deformations in the pavement. Micro surfacing sets by chemical action and a properly designed system will allow the full return to traffic in one-hour. Contract cost is $2.00 to $5.00 per square yard and greatly depends on pavement conditions such as rutting and pavement deformations. Life extension can range from 4 to 7 years depending on pavement suitability.

Thin HMA overlays are considered 1.0" to 1.5" in thickness. Ultra-thin HMA overlays are generally considered 0.5" to 1.0" in thickness. The benefit of a thin HMA overlay is an improvement in ride quality. Average cost nationally of a thin HMA overlay is $6.00 to $8.00 per square yard. Because of the many different underlying pavement conditions, life extensions are difficult to quantify.

Paver placed bonded wearing course, previously known as a Nova Chip, is placed by a spray paver (generally 3-times the cost of a conventional paver) or a standard machine. The product combines a polymerized asphalt emulsion tack coat placed immediately prior to a polymerized ultra-thin HMA overlay. The product has excellent performance properties. Costs vary considerably, ranging from $8.00 to $14.00 per square yard. Sufficient data have not been analyzed to provide a life extension range.

There is no "silver bullet" and every preservation treatment must be applied on the right road at the right time. One of the biggest commonly made mistakes is applying a treatment too late in the pavement life. Research is beginning to show that the performance of the underlying pavement improves with earlier surface treatment applications. Larry stressed the importance of using good quality materials, proper application rates, and attention to detail during the construction process. Polymer modified asphalt emulsions improve performance considerably and justify the additional cost. He also mentioned that scrub seals were included in the NCAT pavement preservation study as a pretreatment and that the results were impressive.

2. *How do you check the construction quality?*

There should be a requirement for the contractor to have a detailed quality control (QC) program. The program should include training standards where both the contractor's and agency personnel pass a certification test to assure competency.

3. *What kind of inspection tests do you run?*

It seems that most agencies conduct different tests depending on the surface treatment being applied. Certain parameters are critical for a successful product. Uniformity of the tests required should be encouraged from agency to agency. Agencies should run tests at the stockpiles and during placement. Random tests on materials should also be included.

4. *What are your expectations from the contractor?*

The contractor must take responsibility for providing a quality product. Contractors who take quality control seriously almost always provide a good-performing, long-lasting treatment.

5. *Do you perform part time or full time inspections during construction operations?*

The saying, "expect what you inspect," is true most of the time. Although full time inspection is not always conducted, it should be.

6. *How do you measure performance?*

The FHWA will soon release performance measures for pavement and bridges. The initial focus will be on the Interstate system and the NHS-non interstate system. Currently, only state DOTs and MPOs will be held responsible for tracking and achieving their pavement condition goals. Who knows if or when the requirement may expand to local agencies?

7. *How do you select a strategy?*

Guidelines should be developed by each agency or group of agencies. It is best to develop these with small groups of capable individuals (around 6-10 people) and then get buy in from the larger group. Standards for selecting the proper treatment should be adopted and applied uniformly. Pushing the boundaries or relaxing the standards will result in problems and reduced performance.

8. *What can be done to make a preservation last longer?*

Apply the treatment at the right time. We need to develop engineering maintenance indicators to select proper strategies, such as oxidation, raveling, bleeding, etc. Also, a pavement preservation project delivery process needs to be faster than the typical construction project delivery process. This may involve streamlining the business process to accommodate applying pavement preservation treatments at the right time. Shorten the timeframe from distress identification and treatment selection to construction.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

In 2002, I had a catastrophic failure of a micro surfacing project on I-94 in Michigan. The micro surfacing was constructed during overnight hours, the lane strips were repainted, and the facility was opened to traffic without any problem. The failure occurred about 2 hours later when a heavy rain began to fall and the micro surfacing re-emulsified. The Department had to set up a phone-bank to handle all the claims. The claims amounted to about $10 million.

All the materials were immediately tested and all successfully passed the required tests. We realized that we (agencies) knew very little about asphalt emulsions. As a result, through the insistence of Jim Sorenson (FHWA), a FHWA Emulsion Task Force of experts was established to address emulsion issues faced by agencies across the country. New AASHTO specifications have been, and are being created to combine asphalt emulsions and preservation treatments into reliable and cost-effective products.

Interview #4: Willy Schacher, North Dakota DOT, Fargo District Maintenance

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Primarily chip seal, some micro surfacing on rutted roads. Fogseals are used for the most part over new HMA pavements. The fogseals are placed shortly after rolling the new HMA mat while the pavement is still warm. The fogseal is applied at 0.1 gal per sq yd diluted to fill surface voids and reduce popouts due to shale and other marginal aggregates in the HMA.

Chip seals are by far the most common surface treatment utilized. Most projects are contracted out. Chip seals are most common because they have provided the best performance at a relatively low cost.

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	Has greatly improved performance of new HMA
Chip Seal	7 years
Slurry Seal	N/A
Micro surfacing	7 years and addresses rutted pavements

2. *How do you check the construction quality?*

Sample aggregate and oil (emulsion) according to Materials Control Schedule.

3. *What kind of inspection tests do you run?*

Yield checks on oil and aggregate to monitor and dial in application rates.

4. *What are your expectations from the contractor?*

The contractor follows method specifications and DOT guidance on application rates.

5. *Do you perform part time or full time inspections during construction operations?*

Full time Inspections are conducted.

6. *How do you measure performance?*

Chip retention. There is typically some chip loss at roadway crown due to underbody plows applying enough force for snow and ice removal beyond chip retention capability.

7. *How do you select a strategy?*

Mainly based on past performance chip seals are the surface treatment of choice. On some mine and blend (pulverization) projects premature rutting has taken place and micro surfacing has been used to fill in the ruts and as a full width surface treatment. This has worked well but is more expensive.

8. *What can be done to make a preservation last longer?*

Crack filling prior to the surface treatment. Applying surface treatment early especially if fogseal is not used on new overlays. Recently a new binder has been introduced showing great promise for dustier aggregates (1.5% P200). The binder is a polymer modified cationic high float rapid set out of Montana (Billings – Western Emulsion). After one year the performance looks good and will continue to be evaluated.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

2 years ago an overlay was placed with high RAP content and marginal aggregates creating a dry mix. There was no money to apply a fogseal on that project and it began to ravel mid-winter. The following spring a MC-250 cutback with a sand cover aggregate was applied to address the distress. This saved the road from failure and it has performed well since.

Interview #5: Bob Rea Nebraska DOT Flexible Pavements Engineer

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Primarily chip seal, some micro surfacing and thin lift HMA overlays. Some fogseals have been applied primarily with CSS-1h emulsion. Specialty fogseals such as Gilsonite have been evaluated in the past and currently they are evaluating two Replay test sections recently placed. The thin lift HMA overlays or SLX are placed after 3/4 inch profile milling. They have found the thin lift SLX surfacing has approximately the same cost as Micro surfacing so SLX is chosen between the two alternatives most of the time.

Chip seals or Armor Coat utilizing a 3/8 inch river gravel is the most common surface treatment utilized. The Armor Coat surface treatments are placed by State Forces and the micro surfacing projects are contracted out. Currently there is a comprehensive study taking place to evaluate the use of lightweight aggregate in their Armor Coat chip seals. The lightweight aggregate is shipped in from Kansas and Colorado and is being evaluated with increased binder application rates and decreased aggregate application rates. Binder application rates have gone from 0.3 gal per sq yd to 0.42 gal per sq yd with the lower weight aggregate.

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	1 to 2 years
Specialty fogseal	currently being evaluated
Chip Seal	5 years
Slurry Seal	N/A
Micro surfacing	5 - 7 years

2. *How do you check the construction quality?*

Seal Coat (Armor Coat) work is done by State forces so placement is controlled by the experienced crew.

3. *What kind of inspection tests do you run?*

Sample aggregate and oil (emulsion) according to Materials Control Schedule. Application rates currently being evaluated as part of a comprehensive study to evaluate changing process over to a lightweight aggregate.

4. *What are your expectations from the contractor?*

N/A – Seal Coat work done by State Forces. Micro surfacing and specialty fog seals must show a positive cost benefit before being adopted as a standard product or procedure.

5. *Do you perform part time or full time inspections during construction operations?*

Full time Inspections are conducted on all contractor surface treatments.

6. *How do you measure performance?*

New product/process performance is evaluated prior to adoption. The comprehensive study to utilize lightweight aggregate in the Armor Coat process will look at the benefits of lighter weight aggregate from performance, safety and cost along with benefits of going to higher binder application rates. Most common currently used binders are CRS-2P and HFE-150.

7. *How do you select a strategy?*

Mostly on a planning cycle. Armor Coats have been placed the 2nd or 3rd year after construction which may be too soon according to Bob. The selection and timing decisions are made by the District offices.

8. *What can be done to make a preservation last longer?*

Expectations are the lightweight aggregate study will lead to longer life pavement preservation.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

Over 10 years ago, the early SuperPave mixes were a somewhat more permeable and asphalt lean mix using a PG 64-22 binder. The mixes aged quickly, became brittle and the armor coat surface treatments exasperated the performance issue. After switching over to a PG 64-34 binder and going to a more dense gradation, the SuperPave mixes have performed very well.

Interview #6: Gill Hedman, SDDOT Research Engineer

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Primarily chip seal w/fogseal, some micro surfacing (contracted out) and thin lift HMA overlays (always contracted. Our maintenance forces will only place patches). Fogseals have been applied primarily with SS-1h or CSS-1h emulsion over new chip seals to assist chip retention. Specialty fogseals such as Gilsonite have been evaluated in the past. Micro surfacing is placed by contract. Rut filling with thin lift HMA patches are conducted with State Forces, typically a scratch course of around 1/2 inches is placed with a rut box. Class S thin lift overlays are 1 to 1 1/4 inches thick placed full width by contractors. Fogseals are also always placed on new overlays to fill surface voids. In this application the fogseal is applied at 0.10 gal per sq yd diluted followed by sand broadcast over the surface and is referred to as a Flush Seal. Fogseals have been found to continue to perform after wearing off the surface aggregate. For most overlays the schedule is to crackseal in year 2 and chip seal with fogseal in year 3 following the overlay. Cold Milling/MicroMilling is being used to texture and profile the surface prior to the overlay. Traffic has been allowed to drive on the micromilled surface from 14 days up to 5 weeks prior to the overlay being placed.

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	3 years
Specialty fogseal	evaluated several years ago but not adopted
Chip Seal	7 years
Micro surfacing	7 years
Micromill and Thin Lift HMA Overlays	15+ years

2. *How do you check the construction quality?*

Test aggregate and emulsion according to the Materials Control Schedule.

3. *What kind of inspection tests do you run?*

Yield checks to assure proper application rates are conducted by field inspectors.

4. *What are your expectations from the contractor?*

Follow the specifications. Specifications for chip seals have been modified to require the contractor to conduct a chip seal design using the Modified McLeod design procedure along with surface texture and other information provided by the State. Oil compatibility is also conducted and a new more simplified procedure is being developed for implementation later in 2016. Anionic emulsions AE150s are used in the central to western portion of the State and cationic emulsions CRS-2P are used in the Eastern portion where glaciated and quarried rock are more available and economical.

5. *Do you perform part time or full time inspections during construction operations?*

Full time Inspections.

6. *How do you measure performance?*

Primarily by appearance. There has been Research work conducted by the South Dakota State University (SDSU) on performance measures but has yet to be published.

7. *How do you select a strategy?*

The Pavement Management System (dRoad) predicts and recommends when pavement preservation strategies like micro surfacing, surface treatments, or rehabilitations like CIR are employed. This is based on inputs of existing distress levels within the system.

8. *What can be done to make a preservation last longer?*

Quality aggregates, compatible materials and good construction engineering. Better construction practices have resulted in longer and better performance of all surface treatments.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

Past pavement issues have been overcome with implementation of the Class S thin overlays. These specialty mixes are similar to SMA in that they have gap gradations with thick asphalt film coating the aggregate. They also utilize a PG 64-34 polymer modified binder. Class S overlays and micro surfacing are used on higher traffic volume roadways.

Interview #7: Dale Heglund, Upper Great Plains Transportation Institute

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Dale provided his perspective based on knowledge of what most local agencies are doing:

Fogseal, Chip seal, Slurry and Micro surfacing. Fogseals are used for the most part over new chip seals. Chip seals are by far the most common surface treatment and slurry/micro surfacing is used to a much lesser extent. The cost depends on many factors but relatively speaking the cost per sq yd is lowest to highest as listed below with the typical lifecycle of each application:

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	N/A
Chip Seal	5 -7 years
Slurry Seal	N/A
Micro surfacing	N/A

Dale indicated that around 10 years ago there were many problems with chip seals bleeding, stripping, tracking and performing poorly. Improvements to the materials, process and binder types have just about eliminated the past problems.

2. *How do you check the construction quality?*

Standard aggregate qualities, gradations and binder quality tests are performed. No special performance tests have been implemented to address specific problems as past issues have been addressed by improved materials and binder types.

3. *What kind of inspection tests do you run?*

Not aware of any inspection tests other than the standard material tests outlined above.

4. *What are your expectations from the contractor?*

The contractor must take responsibility for providing a quality product. The contractors are not currently involved in the surface treatment selection process or material specifications.

5. *Do you perform part time or full time inspections during construction operations?*

Full time Inspections are conducted.

6. *How do you measure performance?*

No measurements other than negative feedback. Currently there is no performance rating system in place.

7. *How do you select a strategy?*

Mainly by past history and comfort level with the process. Recent technical conferences have introduced new strategies that are starting to be used or being considered for future use.

8. *What can be done to make a preservation last longer?*

Introducing the certification program that has been developed through the National Center for Pavement Preservation led by Larry Galehouse. North Dakota Asphalt Conferences have provided specifiers with updates on treatment advancements. Ken Swedeen, DAPA, Tom Wood, MnDOT/MnROAD, and Larry Galehouse, National Center for Pavement Preservation, have been powerful resources and advocates for sharing best practices and new technology in pavement preservation efforts. Conference technology transfer is apparent through the design practices that are being specified.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

No specific project comes to mind but as mentioned earlier, there were many Sealcoat issues that occurred around ten years back. For the most part these problems have been addressed with improved materials and placement processes.

Interview # 8: Todd Weist, Tri- State Asphalt, Morris Illinois

1. *What Pavement Preservation Methods are you providing material for? What are the properties, cost and typical lifecycle of each?*

Tri-State Asphalt supplies binders for surface treatments to Illinois and surrounding states: Fogseal, Chip seal, Slurry, Micro surfacing and Cape Seals. The properties and cost of each relate to the type of materials being used. Micro and slurry primarily differ by the asphalt emulsion since Micro uses a latex modified binder and a slurry does not. However, in most cases the slurry uses more binder (15-16%) than Micro (12%) so the difference in cost can be relatively small. The improved performance and greater applications make Micro a better choice than Slurry. For Chip seals, the cost depends on many factors but asphalt binder is the biggest. High quality and polymer modified asphalt emulsions are underutilized in many areas which would yield higher quality and performance. Aggregates play a large role in cost and overall quality of the surface treatment. Compatibility and proper binder selection based on the aggregate type is crucial to success:

Preservation Method	Typical Lifecycle (application frequency)
Fog Seal	2 to 3 years
Chip Seal	3 to 5 years
Slurry Seal	4 to 7 years
Micro surfacing	4 to 7 years
Cape Seal	8 to 15 years

Todd commented that many Agencies relate slurry with micro surfacing and due to past issues with slurry they are reluctant to use micro. This is unfortunate because micro has shown to be an extremely good performing surface treatment especially when it is placed on top of a chip seal and becomes a Cape Seal. From his viewpoint, many agencies have tried but are not adopting the spray applied rejuvenating products because some products are sold with a "sales pitch and do not perform". Agencies relate the various products together and much like with slurry and micro they will be reluctant to try any product where they have had poor performance with something similar in the past.

2. *Which method to you prefer? Why?*

Cape Seal. Cape Seals have been used in Illinois, Wisconsin and Michigan. In some Illinois Counties they are outperforming overlays at a fraction of the cost. Some Counties are getting 15 years of good performance from Cape Seals while only getting 8 to 10 years from mill and fill overlays. Counties like LaSalle and Kane are expanding their use of Cape Seals based on the performance they have achieved. He also said the Michigan DOT has been using Cape Seals on State and Interstate Highways for a number of years. Todd attributes the superior performance to the combination of a flexible membrane layer from the chip seal combined with a more rigid better wearing surface provided by the micro surfacing.

3. *What are the construction issues?*

When Agencies allow marginal materials such as PG Asphalt Binders and Cutbacks for chip seals versus asphalt emulsions they are creating problems for themselves. Recent emulsion technology improvements provide improved performance but must be specified properly to assure you are not getting inferior products. Anionic High Float binders have better compatibility with certain aggregates like limestone and can accommodate a higher P200 or dust level as well as provide a more suitable charge. Granite and Traprock aggregates absorb less binder and are typically more compatible with a cationic emulsion. The aggregate characteristics vary more than the binders so proper selection of each material is essential for success in each project application. Sometimes washing dirty aggregates is not sufficient to assure success as recycled water becomes dirty and excess moisture and fines left on the rock will cause poor performance on chip seals.

4. *What can be done to make the preservation last longer?*

Education, education, education. Agencies should not adopt a surface treatment strategy based on the best sales pitch. They need to educate themselves or use consultants to assure they are getting the proper materials and applying them in the right way. Sometimes this involves conducting better pavement evaluations before selecting a strategy.

5. *What can be done to help improve quality?*

Use the best products. Use qualified full time inspectors to assure you are getting what you pay for. You cannot expect good performance if the process is not done right.

6. *What is your best alternative to chip seal?*

A Cape Seal or a single lift micro surfacing. The Cape Seal typically utilizes a 3/8 inches chip seal followed by a micro surfacing at about 1/2 to 5/8 inches depth. This has shown to outperform other options but is more expensive than micro surfacing. The cost of cape seal versus the longevity is the best pavement preservation treatment for the money. It's a little more upfront but it allows more time between cycles to fix or repair other roadways.

7. *Any challenging project you want to discuss?*

Projects we supply will perform better because we provide consistent quality from start to finish. When it comes to binders every load should be sampled by the Agency. Testing can be done on randomly selected loads but if test results show a product that barely meets or does not meet specifications then all loads should be tested.

Also, an AMRL/AASHTO accreditation process will soon be adopted requiring all labs that do micro surfacing designs be approved and certified.

Interview # 9: Tara Liske, Province of Manitoba, Canada

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Chip seal, micro surfacing and preservation seals. Preservation seals or fogseals such as Reclamite and CRF have been used. They are evaluating six different surface treatments currently available in Manitoba. These include common treatments such as micro surfacing, chip seals and cape seals along with less common treatments: fiber mat, uniform and racked-in. Uniform and racked-in relate to aggregate used on chip seals and fiber mat utilizes fibers and emulsion placed together in a single application. The test sections were placed in 2014 and will be evaluated the spring of 2016.

Some preservation fog seals were placed in 2008 that are still performing. They protect the pavement surface from shale rock popouts and slow the aging process thus allowing the underlying pavement to perform over a longer timeframe. Treatments used in Manitoba are listed below in order of lowest cost to most expensive with typical lifecycles they have experienced.

Preservation Method	Typical Lifecycle (application frequency)
Specialty preservation fog seal	various lifecycles with some still performing from 2008
Chip Seal	7 years
Micro surfacing	10 to 12 years

2. *How do you check the construction quality?*

Chip Seals are done in house and micro surfacing is contracted out. The key to chip seal performance has been retaining the in-house knowledge and experience they have developed over the years. For micro surfacing they contract with 4 micro surfacing contractors that are based in and outside the Province. There is always a project manager on-site for all micro surfacing projects.

3. *What kind of inspection tests do you run?*

Sample aggregate and oil (emulsion) according to Materials Control Schedule. The chip seal aggregates are typically produced a year earlier so testing takes place during production to ensure compliance with the specifications.

4. *What are your expectations from the contractor?*

N/A for chip seals as they are performed by in–house employees. For micro surfacing projects, method specifications are used and the project manager on site makes sure the specifications are met.

5. *Do you perform part time or full time inspections during construction operations?*

Full time Inspections are conducted on contracted and in-house surface treatments.

6. *How do you measure performance?*

Cracking, rutting and ride data are collected annually to create a surface condition rating which triggers the selection of a surface treatment within their pavement management system (PMS). Chip Seals are no longer used on higher volume expressways due to issues with flying stones kicked up by traffic. New aggregate surfacing criteria is being evaluated in the research work referenced above.

7. *How do you select a strategy?*

There are 8 different condition states within their PMS. Various condition states trigger the proper surface treatment to be utilized which is based on past performance on similar roadways.

8. *What can be done to make a preservation last longer?*

Assuring good quality materials are used within the proper application procedure. In addition, selecting the proper procedure for the existing pavement distress condition is important to extend pavement life. Retaining the highly competent in–house knowledge and experience in properly applying chip seals is very important.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

In the past, some skid resistance issues were overcome by better aggregate selection and quality control.

Interview # 10: LaDonna Rowden, Illinois DOT Engnieer

1. *What Pavement Preservation Methods are you using? What are the properties, cost and typical lifecycle of each?*

Chip seals, slurry seals, micro surfacing, cape seals and ultra-thin bonded wearing course (UTBWC). Sand seals are allowed with an experimental feature, but they have not been tried yet. Illinois pavement preservation program is about 10 years old so life-cycle performance and application frequency are currently being determined by tracking project performance over time. Greater than 5 years pavement life extension has been realized to date. An experimental feature was adopted to fog seal shoulders and is currently being evaluated with treated and untreated sections.

All treatments with criteria for use can be found in Chapter 52 of the Department's Bureau of Design and Environment Manual. Part of the performance tracking includes the use of micro surfacing on deteriorated centerline and pavement edges. The intent being to extend pavement life in these distressed areas to coincide with the rest of the pavement. An issue raised with this practice has been the need for removing and reinstalling raised pavement markings which brings a significant added cost to the treatment. Treatment cost and life-cycle data are continually being gathered in their relatively young program. High variability in costs result from many project factors such as the size of the project and when it is bid or constructed. The costs provided are average bid prices between 2008 and 2015. It should be noted that costs typically drop after surface treatments are adopted and available from multiple contractors.

Preservation Method (lowest cost to highest)	Typical Lifecycle (application frequency)	Illinois Life Extension (Based on minimal sampling)
Fog Seal	about 3 years	N/A (shoulders only at this time)
Sand Seal	N/A	Available but not yet tried
Chip Seal ($2.00/yd2)	5+ years	1 – 6 years
Slurry Seal ($2.70/yd2)	5+ years	1 – 8 years
Micro surfacing ($2.40/yd2 1-pass; $5.50/yd2 2-passes)	7+ years	1 – 8 years
Cape Seal ($5.00/ yd2)	>7 years	2 – 9 years
UTBWC ($9.00/yd2)	>7 years	N/A (still tracking)

2. *How do you check the construction quality?*

No field performance tests are conducted. Aggregate and emulsion/binders are sampled and tested according to the Materials Control Schedule.

3. *What kind of inspection tests do you run?*

Visual inspection of construction process, equipment and materials. Specifications for micro surfacing and slurry seals call for a test strip and calibration of the equipment in the presence of the Engineer. The test strip is only visibly inspected to make sure that the equipment and mix are done properly. Chip seals require the pressure distributer and aggregate spreader to be calibrated in front of the engineer and to the manufacturer's specifications. No inspection or performance tests are run.

4. *What are your expectations from the contractor?*

No warranty criteria so the expectation is the contractor will follow specifications and improve the roadway as expected for the surface treatment they are applying. A visual improvement is very important as the public perception and challenges around spending money on roads that are in better shape than others are always there.

5. *Do you perform part time or full time inspections during construction operations?*

It is a District decision but an Agency representative whether an employee or consultant are present during construction.

6. *How do you measure performance?*

There has been a concentrated effort over the past year to incorporate performance measures. A condition rating survey (CRS) value is assigned to represent the surface condition. The CRS value is used in performance evaluations and establishing a programming backlog to also measure needs. A new pavement is assigned a value of 9 and as the pavement deteriorates the value will drop accordingly. The lowest value a pavement can have is a 1, which represents complete failure of the pavement. The rating system establishes excellent, good, fair and poor ratings, as well as deterioration rates for the pavements.

7. *How do you select a strategy?*

Pavement distresses are listed for the roadway to assist designers in treatment selection and selection tables are provided as guidelines in the previously mentioned Chapter 52.

8. *What can be done to make a preservation last longer?*

Pick the right candidates. Don't allow the pavement to deteriorate beyond the point that the surface treatment is most effective. When this happens the treatment becomes a stop-gap measure to hold a pavement together and the results are disappointing which can set the overall program back.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

A micro surfacing project was placed by a contractor late summer/early fall several years ago which showed many visual deficiencies. A later opportunity to ride the project with the contracting company owner, the agency inspector, and others resulted in a commitment to better quality in the future and increased awareness by the agency and contractor about the importance of doing a good job in order for the Pavement Preservation Program to succeed.

Interview # 11: Al Johnson, WisDOT Maintenance

1. *What Pavement Preservation Methods are you using? What are the properties, cost, and typical lifecycle of each?*

Crack sealing is done to route and seal pavements with less than 10 years old. Chip seal is widely used. Fog seal is also used in some cases to address warranty work requirements but not as a standard surface treatment. Other products such as micro surfacing and rejuvenators are also available, but are not used by WisDOT. WisDOT has had a very limited surface treatment program in recent years (budget related), but recently is starting to renew pavement preservation programs.

Chip Seals: using Class A aggregates meeting wear and soundness specifications is recommend. WisDOT has recently completed friction testing on multiple existing chip seals with different aggregates and ages. The tests have shown the can perform up to 10 to 15 years. Increased friction was also reported.

Slag Seals: when slag is used as the cover aggregate, the treatment is called a slag seal. Black Boiler slags are a special lightweight aggregate which reduces potential for damaged windshields. Slag aggregates are 100% fractured faces, are very dark in color, and very durable. Slags aggregates cost more as the slag has to be hauled by considerable distances which can increase the costs greatly.

Preservation Method	Typical Lifecycle (application frequency)
Fog seal	only done as warranty requirement
Chip Seal	7 to 10 years
Slag Seal	7 to 10 years

2. *How do you check the construction quality?*

A field inspector oversees surface treatment operations.

3. *What kind of inspection tests do you run?*

Aggregates are tested for gradation, wear and soundness, percent of fractured faces, and color (if required by the specifications). Oil samples are sent to Madison (let projects) for lab testing. Also, chip seal designs are required (available) by most of the contractors. These designs include gradations and estimated oil application rates.

4. *What are your expectations from the contractor?*

To provide safety for the travelling public during chip seal placement and to clean up and restore pavement markings. Traffic control usually include one or two pilot cars to direct traffic and control speed. Multiple signs and marks are used including loose gravel signs, advisory speed signs, and temporary raised pavement markers to illuminate centerline and lane lines (if multiple lanes). Also, all the loose chips should be removed prior to removing the pilot cars (broom again the next day, if needed).

5. *Do you perform part time or full time inspections during construction operations?*

Full time Inspectors are assigned to the projects but part time inspections may occur.

6. *How do you measure performance?*

The life of the surface treatment and its short term durability is monitored. Friction tests were completed in 2013 and 2014 on multiple chip seals with different aggregates and ages. The results showed a considerable increase in chip seal life (10 to 15 years of performance).

7. *How do you select a strategy?*

The strategy is to complete the first chip seal by pavement age of 6 to 8 years. The extent of surface raveling, wheel track cracking, oxidation, other early pavement stresses, and pavement marking coordination, determines priorities (based on limited budgets).

8. *What can be done to make a preservation last longer?*

Class A (hard) quality aggregates or slag are necessary for an extended chip seal life. The use of polymer modified emulsion oils also can increase the performance. Also, placing chip seals on pavements in good condition improves performance life; pavements that are rutted or out of shape will have reduced chip seal life due to winter plowing damage.

9. *Any challenging project you want to discuss? Describe the nature of the problems and how you overcame them.*

Utilizing too small cover aggregates have reduced the life of some surface treatments. Too large aggregates have caused windshield breakage in the past. Also, limited aggregate sources can impact price, and consequently, the cost benefit of the treatment.

Appendix C – Certification Program for Pavement Preservation Treatments
National Center for Pavement Preservation

Pavement preservation plays a critical role in safeguarding America's highway system from detrimental effects of the sun, water, and ever increasing traffic. Pavement preservation is a pillar of sound asset management and ensures that the overall condition of the road network can be sustained at a desired level. Therefore, the successful placement and performance of pavement preservation treatments has a dramatic impact on long-term financial planning and the ability of agencies to achieve their pavement condition goals cost-effectively.

In recent years, a substantial number of agencies have adopted a pavement preservation philosophy to keep good pavements in good condition. However, many agencies and contractors lack proper knowledge and work experience in the many pavement preservation treatments available today. Consequently, successful construction and performance reliability are greatly dependent on expertise that is simply lacking. Often, unnecessary failures occur that could easily be prevented with the recognition of targeted training and implementation of certification programs for pavement preservation treatments.

A training and certification program demonstrates that employees possess an understanding and competence to ensure successful pavement preservation treatments. Certification is granted through an exam, and for contractors, additional performance assessments are required. The program is not related to, nor will it infringe on, any prequalification program required by an agency.

Benefits and a Recommended Oversight Process for a State & Local Agency

Having agency personnel certified in specific pavement preservation treatments will ensure that future investments in those treatments are properly designed, constructed, and perform as intended. Certified personnel within an agency will be more knowledgeable about the treatment(s) and be able to assist other agency staff with questions that may arise.

It is understood that project oversight is completely defined and managed by the agency, but a few helpful recommendations can alleviate potential problems:

- Certified personnel within the agency can help serve as the over-arching technical expert for the treatment(s) in the district/region/division.
- Certified personnel can provide peer-to-peer training with other agency staff.
- Certified personnel should attend the pre-construction meeting with the assigned inspector and help review the Contractor's Quality Control Plan; material sources and tests requirements; equipment requirements; and treatment mix design documents if a slurry system will be constructed.
- Certified personnel should witness the on-site calibration of placement equipment used for micro surfacing, slurry seal, polymer-modified slurry, chip seal, or fog seal.
- Certified personnel should be available to respond to treatment issues that may arise in the field.

State & Local Agency Certification

- The state and local agency certification is a voluntary program.
- Certifications are valid for three years.
- Agency personnel may be individually certified for one treatment category or multiple treatment categories. The treatment categories are:
    - Slurry Systems (Micro surfacing, Slurry Seal & Polymer Modified Slurry)
    - Chip Seals and Fog Seals
    - Crack Treatments
- Agency personnel may attend either the ISSA Slurry Systems Workshop[1] in Clark County, Nevada or training by the National Center for Pavement Preservation (NCPP)[2] at the agency's facilities. The ISSA

[1] ISSA Slurry Systems Workshop is offered January 18–21, 2016. Training covers all three treatment categories.

workshop is four-days and covers all three treatment categories. The NCPP training is one-day for each treatment category requested. The certification examination will be administered immediately upon the completion of the training workshop or one-day class.

- Agency personnel must pass a treatment specific examination with a score of 80% or better. The examination is focused on agency needs and will consist of 50 – 75 questions depending on the treatment category.
- Personnel to be considered for certification should include:
    - One senior level inspector and designer from each district/region/division (based on agency nomenclature)
    - One engineering preservation specialist from headquarters/central office
    - Outside consultants providing inspection services for the agency.

Transition toward AMRL Accreditation

The International Slurry Surfacing Association (ISSA) has recently endorsed AASHTO Materials Reference Laboratory (AMRL) accreditation for all laboratories developing mix designs for slurry systems. This ensures that mix designs are developed in laboratories that have a quality management system meeting the requirements of AASHTO R-18. The R-18 requirements titled, "Standard Practice for Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories" contain criteria and guidelines that will initially be for slurry system designs and later transition to include other pavement preservation treatments.

A laboratory can request an assessment for accreditation by registering on the AMRL website. The AMRL schedules assessments on an east-to-west tour of North America, with the complete tour taking approximately 2 years. The purpose of a sequenced tour is to keep assessment cost low. However, if a laboratory requests an immediate assessment "out of sequence" an additional cost would be levied. Laboratories seeking accreditation and conforming to all the requirements will likely have it granted within 3 to 6 months of their assessment. Therefore a reasonable expectation for requiring AMRL accreditation across the nation is about 2 years. Pilot programs can begin requiring AMRL accreditation earlier.

Benefits of AMRL Accredited Laboratories

The AMRL Assessment Program provides on-site assessments of laboratories that perform testing of materials used in construction and the preservation projects. Testing and mix design laboratories gain a great deal from a technically sound assessment by an AMRL accreditation. Through the accreditation process, a laboratory builds a quality management system, which should reduce procedural errors and prevent poor mix designs from going to the field.

Contractor Certification

The contractor's company will carry the burden of certification. Specific certification criteria ensure the contractor's workforce is properly trained to understand quality control measures that result in the highest standard of work and treatment performance. A contractor company certification is valid for one year. Company certification and annual certification renewal will require the following:

- A current listing of field employees at the time of certification or renewal.
- Confirmation of critical experience
    - Company superintendent(s) and company trainer (if designated) have 3 years of specified treatment field experience.
    - Company foreman and/or operators have 2 years of specified treatment field experience

[2] NCPP Training will require a minimum of 20 participants at an agency arranged facility.

- A validation of certification for key employees
    - Company superintendent(s)
    - Company trainer (if designated)
    - Crew foreman
    - Placement machine operator
- A verification of crew/laborer training
    - Completion of ISSA web-based training on the specific treatment
    - Internal training records, that include:
        - A minimum of 4 hours of classroom training by company trainer for each crew/laborer
        - A minimum of 4 hours of on-the-job (OJT) training by company trainer or superintendent for each crew/laborer
- Submission of the company's Quality Control Plan (QCP). This document should define the minimum core efforts required on every project. In addition, a project-specific QCP[3] must be developed and submitted to the agency at the pre-construction meeting.

Company employee certification is valid for three years.

The employee certification process and 3 year certification renewal for key employees is as follows:

- Key employees may be individually certified for one treatment category or multiple treatment categories. The treatment categories are:
    - Slurry Systems (Micro surfacing, Slurry Seal & Polymer Modified Slurry)
    - Chip Seals and Fog Seals
    - Crack Treatments
- Key employees are encouraged to complete ISSA web-based training on the specific treatment as a prerequisite to other training.
- Key employees must attend either the ISSA Slurry Systems Workshop in Clark County, Nevada or training by NCPP at the agency's facilities. The ISSA training is four-days and covers all three treatment categories. The NCPP training is one-day for each treatment category requested.
- Company employees must pass an examination given at a training location in a designated treatment category. The examination will be more comprehensive for company employees than for agency personnel and consist of 50 – 100 questions depending on the treatment category. A passing score will be 80% or better, and passing the examination certifies the employee has a sufficient understanding and knowledge to construct a quality treatment.

Company employee certification carries certain responsibilities to ensure projects are properly constructed. The minimum responsibilities include:

- Superintendent
    - Oversees no more than 3 projects at a time
    - Reviews the project QCP with crew foreman, placement machine operator(s), and crew members
    - Witnesses equipment calibration and test strip placement, unless witnessing is assigned to the crew foreman
    - Ensures certification documentation is available prior to beginning work on the project.

- Crew Foreman
    - Manages and remains on-site for one project at a time
    - Agrees to follow the project QCP
    - Witnesses equipment calibration and test strip placement, unless witnessed by the superintendent

[3] A project-specific QCP would not be needed in the certification documentation.

    - Ensures that field adjustments are limited to the following:
        - Slurry Systems – the addition of additive and water. On occasion, the mineral filler can be adjusted, provided it is the same type material and is within tolerances of the job mix formula (JMF).
        - Chip Seals and Fog Seals – the emulsified asphalt application rate. Pavement textures may dictate an increase or decrease in the application of emulsified asphalt.

- Placement Machine Operator(s) and Crew Members
    - Place treatment according to best practices and procedures

Contractor Company Decertification

A contractor company may lose certification if the NCPP receives supporting documentation from a certified agency that shows a:

- Failure to follow the project Quality Control Plan (QCP).
- Fraudulent action or deliberate misrepresentation
- Failure to submit required documentation for certification renewal by the renewal date

A resolution process has been established to address a contractor appeal of decertification. The process includes the following steps:

- Upon receiving supporting documentation from the certified agency the contractor will be notified of the intent to decertify by the NCPP.
- The contractor must appeal the action in writing to NCPP within 14 days of the notification.
- A resolution team will be assembled to review the appeal. The resolution team will comprise a total of 5 members. There will be 2 members representing the industry, 2 members representing the agency, and 1 representative from NCPP.
- The resolution team will only consider documented evidence.
- The decision of the resolution team is final.

A decertified contractor may not apply for re-certification for a period of one year.

Certification Program Administration

The pavement preservation treatment certification program will be administered by the National Center for Pavement Preservation (NCPP) at Michigan State University. A pilot program is available to any agency that wishes to participate and improve the reliability and performance of their pavement preservation treatments. After piloting the certification program, and if substantial benefits are determined by the pilot agencies, the program may be adopted by the AASHTO TSP•2.

The following fee schedule has been established for the pavement preservation certification program:

Certification Fee Schedule	
ISSA Annual Slurry Systems Workshop (All treatment categories)	
Training Registration* (Contractor Members)	$ 725
Training Registration* (Contractor Non-Members)	$1,050
Training Registration* (Government Agency)	$ 395
Certification Examination	$ 225
NCPP Combined Training & Certification (One treatment category)	
State and Local Agency	$ 200
Consultant	$ 325
Contractor Employees	$ 325
Examination Retake	$ 200
Company Certification & Annual Renewal	
Preservation Contractor	$ 1,250

*Note: Costs identified for ISSA training are based on late registrations. The ISSA gives significant discounts tiered for early registrations made prior to October 22 and December 17, 2015.

Agencies interested in participating in the pavement preservation pilot certification program are invited to contact Larry Galehouse, Director, National Center for Pavement Preservation, at galehou3@egr.msu.edu or telephone 517-432-8220.