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Asphalt Seal-Coat Treatments

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INTRODUCTION

This publication identifies and discusses applications of the various asphalt seal-coat treatments that are available. This publication also describes each of the treatments, the methods of application, advantages and disadvantages, expected performance, and costs. Information contained in this publication will provide a general understanding of asphalt seal coats for the apprentice and identify recent developments in the field for the seasoned road manager.

WHAT'S NEW WITH ASPHALT SEAL COATS?

Did you know that:

- High-float emulsions are being selected for cold regions to improve chip retention.
- Polymer-modified asphalt emulsions are improving the performance of the asphalt cement in a variety of environmental conditions, improving durability and chip retention.
- Asphalt emulsions with rejuvenating properties are being used as fog seals and sand seals to restore aged pavements and seal voids and cracks.
- The "scrub seal" method (figure 1) of using a pull broom following the asphalt-emulsion distributor truck and the sand spreader eliminates or reduces crack-sealing costs.
- Manufactured lightweight aggregates are used to reduce windshield damage caused by loose stones.
- Rapid-setting, low-temperature emulsions exhibit better chip retention on pavement temperatures down to 40 °F.
- Microsurfacing is similar to a slurry-seal application but allows a thicker course to be applied and allows traffic on the roadway sooner.

Figure 1—Distributor truck and scrub broom. (Photo courtesy of Western Emulsion.)

WHY ASPHALT SEAL COATS?

Asphalt seal-coat treatments are mainly a preventive maintenance procedure applied to the asphalt pavement surface to prevent or delay costly corrective measures (figure 2). Asphalt seal coats are surface treatments designed to seal and protect the asphalt pavement from harmful environmental conditions such as sunlight, rain, and snow. Surface treatments are also applied to enhance the wearing properties and improve the traction between the pavement and vehicle tires.

Asphalt seal-coat treatments are surface treatments that will not cure problems beneath the pavement such as a base failure or deterioration of the material beneath the asphalt pavement. Surface treatments work well where the distresses are limited to pavement surface deterioration, or where cracks are not severe. The seal coat limits water from infiltrating through the pavement into the underlying material.

Figure 2—Asphalt distributor. (Photo courtesy of Asphalt Institute.)

WHAT ARE ASPHALT SEAL COATS?

Asphalt seal coats are composed of a thin layer of an asphalt material such as cutbacks, asphalt emulsions, or paving-grade asphalt cement. Modifiers are often added to the asphaltic liquid mixture and may include rubber, latex, polymers, and rejuvenators. Sand, aggregate, mineral and synthetic fillers, and rubber crumbs can be applied after the asphaltic mixture is applied to the pavement surface. Some seal coats such as slurry seals and microsurfacing incorporates the sand, aggregate, and fillers in the mixture before placing it on the roadway.

WHAT ARE PAVING-GRADE ASPHALT CEMENTS, CUTBACK ASPHALTS, AND ASPHALT EMULSIONS?

The asphalt cement used in road construction and maintenance is one of many products refined from crude oil. In order for the asphalt to be used for road maintenance, it must be fluid to effectively coat the aggregate or be dispersed on the roadway evenly. Heating, dissolving in a petroleum solvent, or emulsifying with water allows the asphalt to become fluid. Table 1 summarizes the uses of asphalt materials for surface treatments.

Paving-Grade Asphalt Cements

Paving-grade asphalt cements are made fluid by heating and can be sprayed on the road surface. They are graded according to three different systems: viscosity, viscosity after aging, and penetration. The viscosity-graded asphalt is denoted by the letters “AC” for “Asphalt Cement” followed by a number. The lower the number, the softer the asphalt cement is. Asphalt cement graded by viscosity after aging is denoted by the letters “AR” for “Aged Residue” followed by a number. Again the lower the number, the softer the asphalt is. A third grading method uses the penetration test to grade the asphalt cement and is denoted by numbers. The numbers relate to the depth of penetration of the asphalt cement by a needle under a specific load. The lower the number, the less distance the needle penetrates, and, therefore, the harder the asphalt cement is.

Advantages

The curing time for a paving-grade asphalt cement application is fast because as soon as the material cools, it achieves full strength. It is pure asphalt cement without additives such as solvents or emulsifying agents.

Disadvantages

High temperatures (250 to 350 °F) are required to make the material fluid for construction use. The cover aggregate or sand must be placed immediately before the asphalt cement cools to obtain proper bonding.

Cutback Asphalts
Cutback asphalts are asphalt cements made fluid for construction by the addition of a petroleum solvent such as naphtha, kerosene, or heavy oil. After the liquid material is applied to the road surface, the solvent evaporates, leaving the asphalt cement on the roadway.

The cutback asphalts are graded by curing times, which are denoted by letters; the letters are followed by viscosity-controlled grades, which are denoted by numbers. Rapid-curing (RC), medium-curing (MC), and slow-curing (SC) are the letter designations. A lower grade number following the letter designation indicates that the material includes more solvents and, therefore, is more fluid than a higher grade number. Rapid-curing cutback asphalt is generally not used today because of environmental concerns.

Advantages
Cutback asphalts are applied at cooler temperatures (50 to 250 °F) than paving-grade asphalts. The cutback asphalts penetrate the asphalt pavement better than asphalt emulsions.

Disadvantages
All cutbacks emit hydrocarbons during the evaporation process, which pollute the atmosphere. Cutback asphalts generally cost more than asphalt emulsions. The solvents used in the cutbacks pose a potential fire hazard.

Asphalt Emulsions
Asphalt emulsions use surface-active agents or surfactants to suspend the asphalt particles in water. These surfactants or emulsifying agents are similar to soap, allowing the minute asphalt particles and the water to form a uniform mixture. When the asphalt emulsion is applied to the roadway, the asphalt cement and the water separate. This process is called breaking. The water then evaporates, leaving the asphalt cement and the emulsifying agents behind.

Asphalt emulsions commonly used in road- maintenance operations are either anionic or cationic. The asphalt in the anionic type has a negative electrical charge while the cationic type has a positive electrical charge. Cationic emulsions are denoted by a letter “C” at the beginning of the emulsion type, and the absence of “C” denotes an anionic emulsion. The emulsions are classified by the letters, indicating the relative rate of curing. Rapid-setting (RS), medium-setting (MS), slow-setting (SS), and quick-setting (QS) are the designations. Emulsions are further classified by a number indicating viscosity “1” is more fluid than “2” and a letter for the hardness of the base asphalt (“h” for a harder grade and “s” for a softer grade). High float emulsions are designated with the letters “HF” preceding the emulsion grades.

Advantages
Asphalt emulsions are applied at cooler temperatures (50 to 150 °F) than cutback or paving-grade asphalts. The water evaporating from the emulsion is environmentally safe. Emulsions can be made with a high viscosity to resist runoff on steeper sideslopes and road grades.

Disadvantages
The asphalt and water in the emulsion may separate under boiling or freezing temperatures. Emulsions are not compatible with cutbacks or paving-grade asphalt cements.

Table 1—Uses of asphalt.

Type of Construction	Asphalt Cements															Asphalt Emulsions									
	Viscosity Graded Original						Viscosity Graded Residue				Penetration Graded					Anionic									
	AC-40	AC-20	AC-10	AC-5	AC-2.5	AR-16000	AR-8000	AR-4000	AR-2000	AR-1000	40-40	60-70	85-100	120-150	200-300	RS-1	RS-2	MS-1	MS-2	MS-2h	HFMS-2h	SS-1	SS-1h	CRS-1
Fog Seal																			X			X	X	
Sand Seal																X	X	X						X
Chip Seal				X	X									X	X	X	X							X
Multiple Chip Seal				X	X									X	X	X	X							X
Slurry Seal																						X	X	
Cape Seal																	X						X	
Micro Surfacing																								

WHAT IS COAL TAR?
Coal tar is similar in appearance to asphalt but is produced as a byproduct of bituminous coal during the production of metallurgical coke. Coal tar can be made into an emulsion comparable to asphalt emulsion and applied to asphalt pavement surfaces. Coal tars are used as a surface treatment on roads, driveways, parking lots, gas stations, and airport taxiways.

Advantages
Unlike asphalt cement, coal tar is resistant to damage from gasoline, diesel, oil, salt, and chemicals.

Disadvantages
Coal tar generally costs more than asphalt cement.

MODIFICATIONS OF ASPHALT EMULSIONS
High-Float Asphalt Emulsions
High-float asphalt emulsions (HFEs) are being used more often. Usually, when an emulsion breaks, the remaining emulsifying agent has little effect on the asphalt. This is not so with an HFE. The high-float emulsifying agent creates a gel structure in the asphalt residue. The gel structure permits a thicker

asphalt coating on the aggregate particles. The thicker film prevents raveling and is more resistant to oxidation from exposure to the atmosphere. The high-float residue is resistant to flow at high temperatures while not being affected as much by low temperatures. This allows a softer grade of the base asphalt to be used that will resist bleeding at high temperatures. The softer asphalt does not become as brittle at low temperatures and resists thermal cracking. HFEs are commonly used in hot arid environments with cold evenings.

Polymer-Modified Emulsions
Probably the most common modifier to asphalt emulsions is polymer additives. Polymers and polymer combinations are being modified constantly to enhance the various properties of the asphalt cement binder. Polymers can be used for any asphalt seal coat applications.

Polymers generally used in the asphalt industry are either elastomeric (rubber like) or plastomeric (plastic like). The elastomeric polymers increase the elasticity and flexibility of the asphalt cement, while the plastomeric polymers improve the strength and the durability of the asphalt cement. Polymerized asphalt emulsions are effective in improving stone retention when construction conditions are less than ideal, such as in low air temperatures, shady areas, or sinuous alignment. Polymers can improve the performance of the asphalt binder in both cold and hot temperatures. Some polymers allow the emulsion to chemically break and do not depend on temperature to separate the asphalt cement from the water within the emulsion. This allows the emulsion to break at lower temperatures and provides a longer construction season in some areas or allows surface treatments to be done at night. Polymer modified binders usually cost more, but they increase the performance of the asphalt cement, often reducing life cycle costs.

Rejuvenating Emulsions
As pavement ages, asphalt cement becomes brittle and loses some of its binding qualities. Rejuvenating emulsions penetrate the asphalt pavement, soften the brittle asphalt, and improve the asphalt cement's ability to bind with the aggregate. The rejuvenating agent is also known to heal small cracks in the pavement.

TYPES OF ASPHALT SEAL-COAT SURFACE TREATMENTS

This section briefly describes the types of surface treatments available, some of the advantages and disadvantages, equipment used, relative cost, and expected performance. The cost for each treatment will vary considerably depending on the project size and location, availability of materials, whether the work is performed by a force account crew or private contractor, amount of traffic control required, and other factors. The life expectancy of the various surface treatments will also vary in the amount of asphalt applied, quantity and quality of the asphalt, quality of the cover material, volume of traffic, alignment of the roadway, temperature extremes, ultraviolet exposure, and the use of chains or studs on vehicle tires. The costs and life expectancy should be used for a general comparison between each surface treatment type.

Fog Seal
A fog seal is an application of asphalt emulsion sprayed onto a pavement surface with or without a sand cover (figure 3). The emulsion is diluted to the proper consistency in order to get complete coverage on the roadway but not be too thick to cause a slippery surface. A fog seal works better on a coarse aggregate surface where the asphalt emulsion has room to pond between the aggregate particles. On a smooth aggregate surface, the asphalt rests on the surface covering the top of aggregate particles, creating a slippery surface for the vehicles. If the fog seal was not properly applied and a slippery surface exists, a dry choke cover is applied to the surface. The choke is usually clean sand or aggregate that is less than 0.25 inches in diameter.

Fog seals are used to delay weathering of the pavement, waterproof the pavement surface, improve the pavement's ability to keep water from penetrating the base course or subgrade, and reduce raveling.

Asphalt emulsions with rejuvenating properties such as GSB-Emulsion Sealer and Rejuvenator supplied by Asphalt Systems, Inc. or Reclamite from Witco Corporation can be used to penetrate, rejuvenate, and seal the surface of asphalt pavements. Reclamite requires a thin layer of sand (1 to 2 pounds/square yard) to be applied before allowing traffic onto the roadway.

Advantages
Fog seals are inexpensive compared to other surface treatments. Only a distributor truck is required to apply the fog seal in most cases.

Disadvantages
The expected life of the fog seal is generally shorter than other surface treatments. If applied too heavily, the fog seal could be slippery and hazardous for the road users.

Equipment
The equipment needed for a fog seal is a distributor truck to dispense the asphalt emulsion and a sand spreader if sand is applied.

Figure 3—Fog seal. (Photo courtesy of Asphalt Institute.)

Application
Fog seals are applied at 0.05 to 0.15 gallons/square yard of the diluted asphalt emulsion.

Cost and life expectancy
Typical costs are $0.45/square yard in 1999. The expected life of a fog seal is 1 to 3 years.

Sand Seal
A sand seal is a sprayed application of asphalt emulsion followed by a covering of clean sand or fine aggregate (figure 4). A pneumatic-tire roller is often used after applying the sand. Excess sand is removed from the road surface after rolling.

Sand seals enrich weathered pavements and fills fine cracks in the pavement surface. The sand can provide additional skid resistance to the pavement while also inhibiting raveling.

As in fog seals, emulsions with rejuvenating properties can be used. The additional expense of the rejuvenating emulsion could be cost effective if there are many small cracks in the pavement. CRF Restorative Seal of Witco Corporation and GSB-88 of Asphalt Systems, Inc. are products that are designed to penetrate and restore aged pavements.

Advantages
The sand seal generally provides a thicker coating on the pavement surface than the fog seal, resulting in a longer life expectancy. The sand seal on polished aggregate surfaces can provide additional skid resistance.

Disadvantages
Only fine cracks are filled and larger cracks tend to reappear within a year.

Figure 4—Sand seal. (Photo courtesy of Western Emulsion.)

Equipment
The equipment needed for a sand seal is a distributor truck to dispense the asphalt emulsion and a sand spreader to add the sand cover. A pneumatic-tire roller can be used but is not required. A broom is used to remove the excess sand.

Application
Emulsified asphalts are applied from 0.10 to 0.25 gallons/square yard. The sand is applied at 18 to 25 pounds/square yard yielding a 3/16-inch-thick new layer over the existing pavement.

Cost and life expectancy
The typical costs are $0.70/square yard in 1999. The expected life of a sand seal is 3 to 4 years.

Scrub Seal
The scrub seal process (figure 5) drags a brooming mechanism over the road surface after the asphalt emulsion has been applied to fill the pavement cracks and voids. A layer of sand or aggregate is applied over the emulsion followed by another drag broom, forcing the sand into the emulsion filled cracks and voids. A pneumatic tire roller is then used over the seal. The excess sand or aggregate is broomed off the roadway a couple of hours after application depending on weather conditions.

The Arizona Department of Transportation (DOT) has been using the brooms in the scrub seal method since 1985 and has tried various asphalt emulsions. In 1989 Arizona DOT tried a polymer modified product called Polymerized Asphalt Surface Sealer (P.A.S.S.)™ manufactured by Western Emulsions, Inc. and have been using this product yearly since then. California, Nevada, and Arizona DOTs have been using the scrub seal method with P.A.S.S.™ for the last 5 to 10 years successfully. The road superintendents from these States claim they save money and time by reducing or eliminating the need for sealing the cracks prior to applying the asphalt surface treatment. Another advantage of the P.A.S.S.™ stated by the road superintendents was the forgiving nature of the product that allowed them to place the sand or aggregate 30 minutes after applying the emulsion. The product also accepts less costly, “dirty” sand or aggregate with fines (minus #200 sieve) usually up to 6 percent of the total weight. The DOTs applied the scrub seal and P.A.S.S.™ on highways and freeways.

Figure 5—Scrub seal process. (Photo courtesy of Western Emulsion.)

Golden Bear Division of Witco Corporation manufactures a product called CRF that also could be used with the scrub seal method.

Advantages
The scrub seal method can fill cracks up to 0.5 inches wide that would have normally been filled by crack sealing.

Disadvantages
Many contractors are unfamiliar with the scrub seal method. Tests may be needed to determine what emulsion or polymer-modified emulsion would work with the brooms. If using P.A.S.S.™, the product costs more and may not be available at your locale.

Equipment
The equipment is the same as for a chip seal operation with the exception of the brooming mechanism, which is needed after the emulsion is applied and after the aggregate is spread.

Application
Emulsified asphalt is applied from 0.15 to 0.40 gallons/square yard. The sand or aggregate is applied at 10 to 20 pounds/square yard.

Cost and life expectancy
The cost will vary tremendously depending on the type and quantity of emulsion used, but the typical cost is $1.30/square yard in 1999. The expected life of a scrub seal is 4 to 6 years.

Chip Seal
Chip seals are the most common surface treatment for low-volume roads. A chip seal is an applicationof asphalt followed by an aggregate cover. The asphalt is usually applied as a hot asphalt cement, cutback asphalt, or emulsified asphalt. After the hot asphalt cement, cutback asphalt, or asphalt emulsion is applied to the pavement surface, aggregate is immediately applied over the asphalt before the hot asphalt cement cools or the asphalt emulsion breaks (figure 6). A pneumatic roller is used to reorient or seat the aggregate particles and tighten the rock matrix. After the asphalt cures, the excess aggregate is removed by brooming.

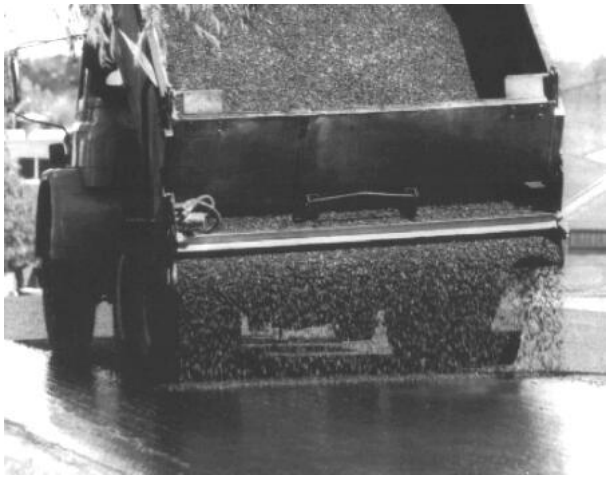

Figure 6—Rock tailgate spreader. (Photo courtesy of Asphalt Institute.)

A chip seal application corrects raveling and seals small cracks on the old pavement surface while providing a new skid resistant surface. Chip sealing may also be used following crack sealing.

If cracked windshields is a significant problem, then volcanic cinders or manufactured lightweight aggregate (LWA) can be used. LWA is manufactured from shale, clay, and slate. These materials are mixed, extruded, and baked in a kiln. Being light in weight, these aggregates have less mass to break a windshield when they become projectiles. The LWA costs more than locally available aggregate and may not be as durable. Reducing loose aggregate and cracked windshields may also be accomplished by using a polymer-modified emulsion with higher quality or smaller sized aggregates.

Also available are rapid-setting, low temperature polymer-modified emulsions designed to “chemically” break at temperatures as low as 40 °F and rising. This type of emulsion would be useful for roads located at high elevations or other areas where the temperatures are lower. The emulsion can also be used where roads are constantly shaded.

Crumbled recycled tire rubber materials are infrequently used in place of aggregate particles.

Advantages
Chip-sealing equipment is common in most areas. The roadway can be opened to low-speed traffic just after the application of the aggregate.

Disadvantages
Chip sealing requires constant attention and frequent adjustment of application rates of aggregate, and especially asphalt, to minimize chip loss, fly rock, bleeding, and other problems. Making these adjustments takes considerable experience and knowledge. Windshields can be damaged by the loose aggregate before the excess is removed, and dust is created during the brooming of the loose aggregate.

Equipment
A distributor truck dispenses the asphalt emulsion, asphalt cement, or cutback asphalt, a rock spreader applies the aggregate, a pneumatic roller reorients or seats the aggregate particles, and a mechanical broom removes the excess aggregate.

Application
Emulsified asphalt is applied from 0.30 to 0.50 gallons/square yard. The type and size of the aggregate particles vary but usually they are between 3/8 to 1/2 inch in size and are uniformly graded and free of fines. The aggregate is applied at 25 to 50 pounds/square yard.

Cost and life expectancy
A typical cost for a chip seal is $1.20/square yard in 1999. The expected life of a chip seal is 4 to 6 years.

Multiple Chip Seals
Often more than one layer of a chip seal treatment is applied to a roadway. Two or three applications can be applied using the same equipment as a single chip seal treatment (figure 7). When multiple layers are applied, the size of aggregate used in the first treatment is larger than the succeeding layers. Multiple chip seals are used to build up a thicker seal coat over an asphalt pavement, as a primed base course, or over a cement-treated base. The number of additional layers would determine the cost of the treatment as well as the life expectancy.

Figure 7—Chip-seal treatment. (Photo courtesy of Asphalt Institute.)

Slurry Seal
A slurry seal is a mixture of quick setting asphalt emulsion, fine aggregate, mineral filler, additive, and water. The ingredients are carefully measured and combined on the project site and spread with a squeegee device. In small areas and parking lots, a hand squeegee is commonly used to spread the mixture. Typically, a specially designed vehicle (figure 8) mixes the ingredients and spreads the slurry. The vehicle has a spreader box towed behind that spreads slurry in a uniform layer. There are three common sizes of slurry seal mixtures. The three mixtures are Type III (3/8-inch minus), Type II (1/4-inch minus), and Type I (1/8-inch minus). Generally, Type I slurry seals are used in parking lots and Type II and III seals are used on streets and higher traffic roads.

Slurry seals will fill small surface cracks, stop raveling, and improve the skid resistance of the pavement.

Advantages
The surface of a slurry-seal treatment is smoother than a chip seal treatment. The slurry-seal treatment is, therefore, more “surface friendly” than a chip-seal treatment in areas such as campgrounds. A person is able to rollerblade on a slurry-seal treatment.

Disadvantages
Equipment to apply a slurry seal is not as common as the equipment for a chip-seal application. Many counties, which are partners with the U.S. Department of Agriculture, Forest Service, as well as local contractors, own equipment for chip seal applications but not slurry-seal equipment.

Equipment
Mixing equipment is needed onsite to accurately combine the components. For all road applications a special slurry truck is needed to mix and apply the slurry.

Application
The slurry mix is applied at the thickness of the largest aggregate in the mix. The amount of aggregate, filler, additives, and water is based on the mix design, depending on the component materials, environmental conditions, and existing road surface.

Cost and life expectancy
The typical cost is $1.20/square yard in 1999. The life expectancy is 4 to 6 years.

Figure 8—Slurry seal application. (Photo courtesy of Asphalt Institute.)

Cape Seal
A cape seal is an application of a chip seal followed by a slurry seal. The term “cape” is derived from Cape Province of South Africa where this process was developed.

A chip seal is applied to the road, then the excess aggregate is removed after the asphalt has cured. The slurry is then applied over the chip seal treatment. The Willamette National Forest in Oregon applied a cape seal in 1997 to evaluate the effectiveness of this treatment. The slurry seal was applied over a cement-treated base.

Advantages
The cape seal increases the life of a chip seal by enhancing binding of the chips and by protecting the surface. The cape-seal surface does not have any loose aggregate and creates a dense mat.

Disadvantages
Equipment for both the chip-seal treatment and the slurry-seal application is required. The construction process is longer than either a chip-seal treatment or a slurry-seal application.

Equipment
The asphalt distributor truck dispenses the asphalt emulsion, an aggregate spreader vehicle is required, a pneumatic roller (figure 9) is used, and a broom removes the excess chips. A slurry mixer and dispensing vehicle are needed to apply the slurry.

Application
The application is the same as the chip and the slurry seals stated earlier.

Cost and life expectancy
The typical cost is $2.00/ square yard in 1999 with a life expectancy of 6 to 8 years.

Microsurfacing
Microsurfacing (figure 10), while similar to a slurry- seal operation, allows a thicker layer to be placed (0.4 to 0.6-inch thick) and cures faster than a slurry seal. Microsurfacing uses a polymer-modified emulsion mixed with crushed aggregate, mineral filler (cement, lime, limestone dust, flyash), water, and additives. The additives influence the mix time and set time.

Advantages
Microsurfacing can be placed in a thicker layer than a slurry seal and, therefore, can be used to fill wheel ruts and correct minor leveling problems. It has a quicker cure time so traffic can be allowed on the road sooner than a slurry seal. It is a cold system with a temperature limitation of 50 °F and rising. This allows many microsurfacing operations to be done at night.

Disadvantages
Microsurfacing requires special equipment that is heavier and sturdier than a slurry machine. The cost is higher than a slurry- or chip-seal treatment.

Equipment
A special microsurfacing self-propelled machine is used.

Application
The microsurfacing mix is applied up to 0.6 inches in depth. Wheel ruts up to 1.5 inches in depth can be filled with a single pass. The amount of each material used is determined by the mix design.

Cost and life expectancy
The typical cost is $1.50/square yard in 1999. The life expectancy is 6 to 8 years.

Pavement Dressing
Pavement dressings are emulsions made from asphalt, coal tar, or a combination of both. They may include rejuvenators and a variety of fillers such as fibers and mineral fillers. Polymer modified asphalt emulsions are also used in some of the pavement dressings. Pavement dressings are used for, but are not limited to, campgrounds, administrative sites, parking lots, and driveways. The pavement dressings containing coal tar are used where protection from petroleum spills are needed. This material is sprayed or squeegeed onto the pavement.

The pavement dressings fill small cracks, and seal and protect the asphalt pavement from oxidation and deterioration.

Advantages
Pavement dressings can be applied in small quantities such as on a driveway or walkway and do not require special equipment. The treated surface is smooth, similar to a slurry seal.

Disadvantages
Pavement dressings are not cost effective on roadways when compared with other surface treatments.

Cost and life expectancy
The typical cost is $0.75/square yard in 1999. The life expectancy is 4 to 6 years.

SUMMARY

This publication identifies asphalt seal coat treatments commonly used today. The road manager still must determine the appropriate treatment based on variables unique to the road, such as the road condition, climate, traffic level, time of year in which the treatment is applied, availability of materials, availability of funds, cost of treatment, life expectancy of treatment, and other factors. The road manager should consult the geotechnical engineer to jointly determine the most cost-effective seal coat treatment, which may not be the least expensive alternative.

APPENDIX A

Asphalt Pavement Distresses

A survey of the pavement must be conducted before a treatment can be determined. There are many types of distresses, and the severity of each will vary. The same pavement normally has a combination of distresses. Some pavement distresses are described with a suggested surface treatment. Table A1 at the end of this appendix summarizes these surface treatments.

Raveling and Surface Wear

Raveling is the loss of aggregate particles on the pavement surface. This could be caused by the loss of the binding properties of the asphalt in the mix due to oxidation and/or asphalt stripping. When these two problems occur, vehicle tires can wear wheel paths by raveling off coarse aggregate. Wear is usually caused by studded tires, traction chains, or snow plows.

Severity	Description
Low	The pavement is slightly rough.
Medium	The pavement is moderately rough.
High	The pavement is very rough and deeply pitted.

Treatment

Any of the asphalt seal coat treatments could improve a pavement with raveling problems. For low-severity raveling, a fog seal could treat the problem while a chip seal or slurry seal would be needed for medium to high severity raveling. A rejuvenating treatment may also restore the binding properties of an aged pavement surface. Surface wear problems are normally solved by chip or slurry seals.

Rutting

Rutting is a depression in the surface of the asphalt pavement caused by the deformation of the asphalt mix within the vehicle wheel path. The deformation could also be caused by the deformation of the subgrade under the pavement. When the rutting is severe, the edges of the rutted area may be elevated. If the rutting is caused by the movement in the subgrade or an unstable mix, a surface treatment will not fix the problem.

Severity	Depth of rut
Low	0.25 to 0.50 inches
Medium	0.50 to 0.75 inches
High	over 0.75 inches

Treatment

Microsurfacing has been used to fill ruts that are low to medium in severity. The most common method for eliminating wheel ruts is an asphalt mix overlay. If ruts are severe and the traffic volume is high, removal and replacement of the pavement may be the only successful long-term solution.

Cracking

Cracks are a separation of the pavement and are categorized by the alignment of the cracks in relation to the road centerline. The width of the crack opening will vary because of the expansion and contraction of the pavement, degree of pavement oxidation, traffic volume, frost heave, and so on. Some cracks exhibit much more movement than others. Cracks are wider in the winter when the pavement is cold.

Longitudinal Cracking—Cracks that are parallel to the centerline of the roadway are longitudinal cracks. These cracks tend not to exhibit as much movement as transverse cracks; therefore, they are considered nonworking cracks as determined by the Strategic Highway Research Program study. If the longitudinal cracks are located in the wheel tracks, they must be treated to prevent alligator cracking.

Transverse Cracking—Cracks that are perpendicular to the centerline of the roadway are transverse cracks. These cracks are most likely to be caused by the shrinkage of the pavement. The longer the distance between the transverse cracks, the more lateral movement the crack will exhibit. As with any type of cracks in the pavement, the width of the opening will vary because of the expansion and contraction of the pavement. The cracks are wider in the winter when the pavement is cold.

Block Cracking—Block cracking is a series of cracks that form block-shaped patterns. These rectangular shapes vary in sizes from 1 foot square to 10 feet squares. These can be caused by subgrade settlements, age hardening, or oxidation of the asphalt. In northern climates, these are often caused by frost heaves.

Alligator Cracking—Alligator cracks are associated with vehicle loading and, therefore, tend to appear within the wheel tracks. These cracks begin as longitudinal cracks, and the damaged area progressively increases in time, if not treated. The cracks interconnect and form a pattern similar to the skin of an alligator. Alligator cracks are normally associated with pavement structural failure.

Severity	Width of crack opening
Low	Less than 0.25 inches wide.
Medium	Greater than 0.25 inches wide with no spalling on the edges.
High	The cracks are spalled (chipped of fragmented) on the edges and there may be several adjacent cracks.

Treatment

Crack sealing or filling is the most common method to prevent water or incompressibles from entering the cracks with low to medium severity. Sand seals, chip seals, or scrub seals may also treat the cracks of low to medium severity. Cracks that are numerous and spalled on the edges may require skin patching with fabric or rehabilitation.

Flushing
Flushing or bleeding is the result of the excess asphalt moving upwards in the pavement, causing a bituminous film on the pavement surface. This could be caused by an improper asphalt concrete mix or an improperly applied seal-coat application. The visible sign of flushing is a shiny pavement surface. Flushing can be dangerous because it reduces skid resistance of vehicles, especially when the pavement surface is wet.

Severity	Within the affected area
Low	Some of the surface aggregates have been covered by asphalt.
Medium	Significant amount of the surface aggregate has been covered by asphalt.
High	Most of the aggregate has been covered by asphalt.

Treatment
For low- to medium-severity flushing, the simplest treatment is to apply sand over the affected area to act as a blotter for the excess asphalt. For medium- to high-severity flushing, a pavement milling machine is used to remove the excess asphalt. Using a high-float emulsion with a chip seal may also prevent flushing.

Polished Aggregate
This occurs when the top surface of the aggregate particles is polished smooth. The surface becomes very slippery when wet.

Severity	Within the affected area
Low	A small portion of the surface aggregate has been polished smooth.
Medium	Significant amount of the surface aggregate has been polished smooth.
High	Most of the aggregate has been polished smooth.

Treatment
For all severity levels of polished aggregate, the surface requires a skid-resistant treatment. Surface treatments including sand seals, chip seals, or slurry seals can be applied over the affected area.

Table A1—Possible treatments for distresses and typical cost and life expectancy of treatment.

Possible Treatment for	Fog Seal	Sand Seal	Scrub Seal	Chip Seal	Multiple Chip Seal	Slurry Seal	Cape Seal	Microsurfacing	Pavement Dressing
Raveling and Wear	X	X	X	X	X	X	X	X	X
Rutting								X	
Cracking		X	X	X	X	X			
Flushing				X	X				
Polished Aggregate	X	X	X	X	X	X	X	X	X
Typical Cost ($/sq yard)	$0.45/sq yard	$0.70/sq yard	$1.30/sq yard	$1.20/sq yard	Depends	$1.20/sq yard	$2.00/sq yard	$1.50/sq yard	$0.75/sq yard
Typical Cost ($/sq/meter)	$0.54/sq meter	$0.84/sq meter	$1.55/sq meter	$1.44/sq meter	on number	$1.44/sq meter	$2.39/sq meter	$1.79/sq meter	$0.90/sq meter
Life Expectancy	1 to 3 years	3 to 4 years	4 to 6 years	4 to 6 years	of layers	4 to 6 years	6 to 8 years	6 to 8 years	4 to 6 years

Note: Costs are based on 1999 data.

APPENDIX B

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APPENDIX C
Suppliers

Lightweight Aggregate

Expanded Shale, Clay and Slate Institute
2225 Murray-Holladay Road
Suite 102
Salt Lake City, UT 84117
801–272–7070

Scrub Seal

Western Emulsions, Inc.
382 East Live Oak
Irwindale, CA 91706
818–358–8049

Golden Bear Products
Witco Corporation
P.O. Box 456
Chandler, AZ 85244–0161
602–963–2267

Organizations

Strategic Highway Research Program (SHRP)
U.S. Department of Transportation, Federal Highway Administration
Information Clearinghouse
http://209.48.224.225:80/shrp/

U.S. Department of Transportation, Federal Highway Administration
Office of Technology Applications
400 7th St. SW
Washington, DC 20590
http://www.fhwa.dot.gov

Local Technical Assistance Program (LTAP)
American Public Works Association
1301 Pennsylvania Avenue, NW
Suite 501
Washington, DC 20004–1701
202–347–7267
http://www.ltapt2.org

Transportation Research Board
http://www.nas.edu/trb/

National Technical Information Service
U.S. Department of Commerce
Springfield, VA 22161
703–605–6000
http://www.ntis.gov/

American Association of State Highway and Transportation Officials (AASHTO)
444 North Capitol Street, NW
Suite 249
Washington, D.C. 20001
202–624–5800
http://aashto.org

Asphalt Institute
P.O. Box 14052
Lexington, KY 40512–4052
606–288–4960
http://www.asphaltinstitute.org/

National Association of County Engineers
440 First Street, NW
Washington, D.C. 20001–2028
202–393–5041
http://www.naco.org/affils/nace

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