Mustansiriyah University / College of Engineering

Highway &Transportation Engineering Department

Highway Maintenance Course

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Lecture Three (Part 2)

Maintenance Techniques

Surface treatments

Surface treatment is a thin layer of asphalt surface treatment (25mm or less in thickness) that can be placed on any type of asphalt pavement surface. They are formed by the application of an asphalt emulsion, cutback or asphalt binder (**seal coat**) plus aggregate (**chip seal**) to protect or restore an existing pavement surface.

- An asphalt treatment that consists of a sprayed on coat of an asphalt binder, emulsion or cutback that is followed by aggregate that is spread on top is known as a **chip seal**.
- A chip seal is also known as surface dressing, armor coat, or seal coat.
- The term "seal coat" can also be used interchangeably with the term "chip seal" or even the broader term "surface treatment."
- Applications of a pavement sealer has also been called **seal coat**.
- The interchanging of the terminology can be confusing. The term "seal coat" will refer to the application of a pavement sealer. The engineer or maintenance professional responsible for the maintenance of parking lots will usually encounter the term "seal coat" as referring to the application of **a pavement sealer**.
- One function that a surface treatment will not provide is **structural strength**. The lack of any significant aggregate interlock and thickness in a surface treatment results in no structural strength and is not considered when determining the overall required thickness for an asphalt pavement.
- In some instances, a thin layer of an **asphalt mixture**, usually less than **25mm** thick, is used as a surface treatment. The mixture is usually **dense graded** HMA with a maximum aggregate size of **9.5mm or less**. Thin surfacing or scratch coat are terms that can be used to describe the thin application of an asphalt mixture.

The surface treatment will perform one or more of the **following functions**:

1- Provide a weather resistant surface.
2- Provide a fuel or oil resistant surface.
3- Provide an esthetically pleasing coating to the pavement surface.
4- Fill or seal hairline or cracks under 3mm width.
5- Fill distortions or rutting.
6- Provide a skid resistant surface.

Surface treatments can be sub-grouped into three classes:

1- Pavement sealers,
2- Chip seals,
3- Slurry seals.

The difference between the three is that pavement sealers contain essentially no aggregate (except possibly small amounts of clay or sand) and chip seals and slurry seals contain a significant portion of aggregate.

The use of pavement sealers

- Pavement sealers are used to restore or rejuvenate an oxidized asphalt pavement surface.
- They are also used to fill hairline cracks that are less than 3 mm wide.
- Some sealers provide an improved or "new" appearance to an aged asphalt pavement and can protect the asphalt pavement from fuel or oil damage.
- Pavement sealers can be both **preventative** and **corrective** maintenance.
- The most common use of pavement sealers is for preventative maintenance and to improve the appearance of an asphalt parking lot.
- Sealers can cover up old parking stripes allowing new stripes to be painted on the parking lot.

The most common pavement sealers are:

1- Fog seals,
2- Asphalt emulsion seal coat, and
3- Coal tar seal coat.

Fog seals

A fog seal is a very light application of an asphalt emulsion.

The use of fog seal:

1- Fog seal is used to renew old or oxidized pavement surfaces that have become brittle.
2- It is used to seal hairline cracks.
3- It also coats aggregate particles at the surface of pavement.
4- It can prolong the pavement life and possibly delay major maintenance if applied in time.
5- Fog seals are also used as a dust palliative on gravel and dirt roads.

The method of application of fog seal:

- The asphalt emulsion is sprayed, usually through an asphalt distributor truck (**Plate 9.14**), on the pavement surface.

- The application rate is in the range of 0.4–0.7 l/m^2.
- The asphalt emulsion is usually diluted one to one with water to provide an asphalt binder content of around 30 percent.
- The asphalt emulsion used is a slow setting emulsion, either anionic or cationic.
- SS-1, SS-1h, CSS-1, and CSS-1h type asphalt emulsions can be used for fog seals.
- Over application of the fog seal should be avoided. Over application is led to tracking of the residue asphalt emulsion by vehicles and pedestrians and has the potential for skid resistance problems. If excess application of the fog seal is encountered, a light application of the sand should correct the problem.
- Fog seals **do not last very long** with an annual application usually considered adequate.
- The spray bar height is constantly maintained even as the load on the distributor becomes lighter. Normally, as the distributor became lighter on the truck springs and shocks, the spray bar height would slightly increase. Most modern distributors can compensate for the loading by automatically adjusting the spray bar height. In order to prevent the spray pattern from interfering with each other, the nozzles are offset from the spray bar axis at an angle of 15–30.

Plate 9.14 The back of a distributor truck.

Table 9.11 Spray temperatures for pavement sealers and surface treatments

Material type	*Emulsion type*	*Spray temperature* (°C)
Asphalt binder	AC-2.5, AC-5	140–200
Asphalt binder	asphalt penetrations >120 dmm	130–180
Asphalt cutback	70 grade	50–105
Asphalt cutback	250 grade	75–130
Asphalt cutback	800 grade	95–150
Asphalt cutback	3,000 grade	110–175
Slow set emulsion	SS-1, SS-1h, CSS-1, CSS-1h	25–40
Medium set emulsion	MS-1, MS-2, MS-2h, HFMS-1, HFMS-2, HFMS-2h, HFMS-2s, CMS-2	30–50
Rapid set emulsion	RS-1, RS-2, HFRS-2, CRS-1, CRS-2, CRS-2P	50–90
Coal tar sealers	≥40% solids	10–35

The total flow rate of the asphalt material onto the pavement surface is controlled by three variables:

1- Proportioning flow valve,
2- Asphalt pump output measured by a tachometer and pressure gauge, and
3- Bitumeter equipped with an odometer. عداد المسافات

A **Bitumeter** is a device that measures the asphalt distributor's travel rate. It is equipped with a rubber tire wheel mounted on a retractable frame that records the distributor's progress in meters per minute and total meters traveled. The device then computes the liters per square meter sprayed on the pavement surface and reports it on a display in the cab.

The required amount of asphalt material to be sprayed for a given area can be determined by equation.

Total liters = W*L*R

where W is the pavement or area width or spray bar width (m); L, the pavement or area length (m); R, the application rate (l/m^2).

Example

Determine the amount of liters of diluted CSS-1 emulsion to be sprayed as a fog seal on a parking lot of 500m by 1,350m area at an application rate of 0.5 L/m^2.

Solution:

Total liters required = (500 m)(1,350 m)(0.5 l/m^2)=337,500 L of diluted emulsion.

If the emulsion is diluted one to one; the emulsion amount will be **337,500/2 = 168,750 L** of CSS-1 will be required to spray the fog seal.

Example

Determine how much of a pavement a distributor with a 2 m spray bar and 10,000 L tank spraying a fog seal at 0.6 l/m^2 can spray in one pass.

Solution:

Total liters=W*L*R

Using equation: length passed by the distributor =10000/(2*0.6) = 8,333m

Table 9.14 Fine aggregate gradation for sealcoating

Sieve size	Total passing (%)
2.36 mm	100
1.18 mm	95–100
600 µm	60–95
300 µm	10–40
150 µm	0–10
75 µm	0–2

Table 9.16 Typical sealcoat application rates

Pavement use	Number of coats	Application rate (l/m^2)	Sand rate (kg/l)
Commercial parking area	Two sand coats	0.5	0.6
Parking lot drive lanes	One prime coat (no sand) Two sand coats	0.6	0.8
Residential drives	One sand coat	0.4	0.5
Refueling areas	Three sand coats	0.5	0.7

Table 9.17 Surface condition application rate addition

Pavement surface condition	Sealer application increase (l/m^2)
Smooth or dense surface	+0
Medium or average texture, slightly oxidized	+0.1
Some raveling, slightly oxidized	+0.3
Rough texture or severe oxidation	+0.4
Excessively rough texture	+0.5

Chip seals

A **chip seal** is a surface treatment as a form of sealcoating with the exception that a thin layer of coarse aggregate is spread onto a previously sprayed application of an asphalt binder, emulsion, or cutback.

- The term **chip** refers to a nearly single size, and usually crushed coarse aggregate.
- "Chip seal" is another term for surface dressing.
- Seal coat has also been used to describe a chip seal, seal coat only refers to an application of a pavement sealer, usually containing a small amount of fine aggregate, to the pavement surface.
- **Chip seals also do not add any structural strength to the pavement and is considered either a maintenance activity or a method to upgrade a gravel or dirt road.**

Chip seal materials

Asphalt **emulsions** are the most common types of asphalt materials used for chip seals. The emulsions have **replaced** for the most part, the **cutback** asphalt used for chip seals.

- Air quality concerns are restricting or eliminating the use of cutback asphalt.
- Soft asphalt binders can also be used for chip seals.

Table 9.18 Asphalt materials for chip seals

Asphalt material class	*Material type*
Asphalt binders	Penetration ⩾120 dmm
Cutback asphalt	RC-250, RC-800, RC-3000
	MC-800, MC-3000
Anionic emulsion	HFE-90, HFE-150, HFE 300
	RS-1, RS-2
	HFRS-2
Cationic emulsion	CRS-1, CRS-1P, CRS-2, CRS-2P

Table 9.21 Typical gradations of chip seal aggregates

Sieve size	*Nominal top size* (mm)			
	25	19	12.5	9.5
	Total passing (%)			
25.0 mm	100	100	100	100
19.0 mm	90–100	100	100	100
12.5 mm	20–55	90–100	100	100
9.5 mm	0–15	40–70	85–100	100
4.75 mm	0–5	0–15	10–30	85–100
2.36 mm		0–5	0–10	10–40
1.18 mm			0–5	0–10
300 μm				0–5

Chip seal construction

Prior to any surface treatment, the structurally deficient portions of the pavement should be **repaired**. Patches should be installed where required and significant cracking should be filled or sealed. Patches and crack repairs should have enough time to cure prior to the application of the chip seal. The chip seal will not correct any structural weaknesses or drainage problems in the existing pavement. The construction of a chip seal consists of the following steps:

1- Make improvements to the pavement's drainage, if needed.
2- Patch potholes.
3- Seal or fill significant cracks.
4- Clean the pavement surface.
5- Spray the asphalt material at the specified rate and temperature.

6- Immediately spread the cover aggregate at the specified rate after the spray application. An asphalt emulsion will still be brown in color.
7- Roll the cover aggregate to seat them into the asphalt material.
8- After curing or setting, sweep any loose stones.

Four pieces of equipment are used in constructing chip seals:

1- **Power broom**, the first step in the chip seal process is the removal of all dirt, dust, and clay from the existing pavement surface. Any standing water needs to be drained or removed. Sweeping with a power broom will remove any significant dirt or debris from the pavement surface. When the chip seal is going to be placed directly on a granular base or dirt or gravel road, the existing surface should be shaped into the desired cross-section and compacted.
2- **Asphalt distributor**, a prime coat should then be applied. The prime coat should be completed sufficiently ahead of the chip seal operation, so that the prime coat has penetrated the base as completely as possible and has properly cured or set. Prime coats are usually applied at a rate of 2.0 l/m^2 for a very tight and impervious base up to a rate of 7.0 l/m^2 for a very porous or loose base.
3- **Aggregate spreader**, and
4- **Pneumatic roller**.

Types of chip seals

There are various types of chip seals that can be used with the single chip seal being the most common and the foundation of the other types of chip seals.

1- ***Single chip seal*** is an application of an asphalt material directly on a road, followed by a single application of aggregate. It is the most common method and is adequate for most roads with light to medium traffic levels.
2- ***Double chip seal*** is a second chip seal put directly on top of a single chip seal.

- There is a second application of asphalt material followed by the addition of a layer of aggregate that has a maximum top size of about 50 percent of the first chip seal.
- There is no increase in thickness since the smaller particles fit between the larger aggregate particles.
- A double chip seal will provide about three times the service life for about one-and-a-half times the cost.
- The packing in of additional smaller aggregate by the single application results in a chip seal with a significant reduction in aggregate loss.
- A double chip can be used for roadways with higher levels of traffic.

3- ***Triple chip seal*** is similar to a double chip seal with even smaller aggregate for the third aggregate application. A triple chip seal is often used for high speed or high traffic applications.

4- Sandwich seal is a chip seal that is constructed by spreading a single layer of large aggregate (15–20 mm) directly on the road surface, followed by the application of the asphalt material, and lastly followed by a second application of aggregate, but much smaller (5–12 mm). The application of the larger aggregate is used to overcome flushing or bleeding problems in the existing pavement surface and the smaller aggregate locks in the larger aggregate.

Table 9.28 Typical chip seal application rates

Nominal top size of chip seal (mm)	*Chip seal spray rates, asphalt emulsion* (l/m^2)	*Chip seal aggregate spread rates* (kg/m^2)	*Type II slurry seal* (kg/m^2)
19	1.3–1.8	14–16	2.5–4.5
25	1.6–2.2	22–27	3.5–5.5

Slurry seal

A **slurry seal** is a surface treatment that can be used for both preventative and corrective maintenance.

- Like other surface treatments, a slurry seal will not increase the structural strength of the pavement or correct major deficiencies.
- The same repairs that would be done prior to a chip seal should also be done prior to the application of the slurry seal.

The functions of slurry seal:

1- A slurry seal will fill minor cracks,
2- slow or stop raveling,
3- improve skid resistance,
4- provide protection from water damage, and
5- reduce oxidation and increase the service life of pavements that are already in relatively good condition.

Differences between chip seal and slurry seal:

- A slurry seal differs from a chip seal in that the aggregate is dense graded and premixed with an asphalt emulsion before it is laid, while the aggregate in chip seal is one sized aggregate laid down after the seal material (bitumen or emulsion).
- Chip seals are usually not permitted on aircraft runways or taxiways due to the possibility of loose aggregate ingestion by a jet engine. Loose aggregates are not a common problem with slurry seals and are often used on runways.
- Slurry seal does not need to be compacted like a chip seal, but it can be if desired.

- The same repairs that would be done prior to a chip seal should also be done prior to the application of the slurry seal.

The benefits of a slurry seal are:

- Fast application and quick return of traffic.
- No loose cover aggregate.
- Dark black appearance and esthetically pleasing.
- Excellent surface texture and skid resistant.
- Ability to correct minor surface irregularities.
- Very minimum loss of curb heights, manholes, and other drainage structures.
- No need for manhole or drainage structure adjustments.
- An excellent surface treatment for urban applications.
- An excellent surface treatment for aircraft runways.

Microsurfacing

Microsurfacing is a form of slurry seal. The construction techniques and precautions that apply for slurry seals also apply for microsurfacing. It is designed using the same methods and uses the same materials except for a few noted exceptions:

- Uses the Type III slurry seal gradation (finer gradation),
- Requires all crushed aggregate, and
- Uses a polymer modified cationic, quick set emulsion (CQS-1P).

The effect of the use of polymer and crushed aggregate:

- The addition of the polymer and requiring all crushed aggregate increases the **stability** and **stiffness** of the cured slurry seal or microsurfacing. The increased stability and stiffness allows the slurry to be laid in thicknesses up to 50mm as rut-filling mixtures. Rutting on pavements that are otherwise stable can have the ruts filled to eliminate vehicle hydroplaning in the ruts or channels. Special rut-filling spreader boxes allow deep pavement ruts or channels to be filled with the microsurfacing mixture.
- Microsurfacing is typically spread in thicknesses of 9–16 mm. These thicknesses require application rates of 11–16 kg/m^2.
- Microsurfacing can also be spread in two or more lifts.
- The stronger microsurfacing can undergo heavier and greater traffic loads than a standard slurry seal.

• Microsurfacing will set fairly fast due to the use of quick set emulsifiers in the asphalt emulsion.

Table 9.29 Slurry seal emulsions

Anionic	*Cationic*
SS-1, SS-1h, QS-1h	CSS-1, CSS-1h, CSS-1P, CQS-1h, CQS-1P

Table 9.30 Slurry seal aggregate quality requirements

Test	*Requirement*	
	Slurry seal	*Microsurfacing*
Sand equivalent value, ASTM D2419	⩾45%	⩾60%
Sodium sulfate soundness, ASTM C 88	⩽15%	⩽15%
Los Angeles abrasion, ASTM C 131	⩽35%	⩽30%

Table 9.31 Slurry seal gradation types and application rates

Sieve size	*Slurry seal type*		
	I	*II*	*III*
	Total passing (%)		
9.5 mm	100	100	100
4.75 mm	100	90–100	70–90
2.36 mm	90–100	65–90	45–70
1.18 mm	65–90	45–70	28–50
600 μm	40–65	30–50	19–34
300 μm	25–42	18–30	12–25
150 μm	15–30	10–21	7–18
75 μm	10–20	5–15	5–15
Residual asphalt binder content, % weight of aggregate	10–16	7.5–13.5	6.5–12
Application rate (kg/m^2)	3.5–5.5	5.5–9.0	8.0–14.0

Plate 9.15 Distributor spray bar.

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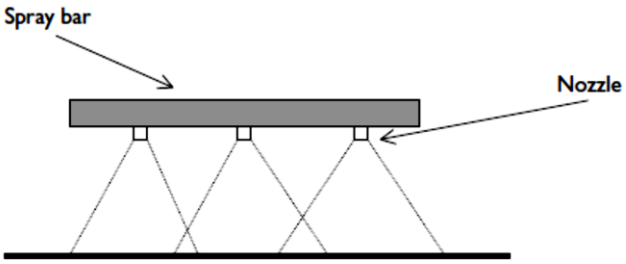

Figure 9.4 Spray nozzle coverage and overlap.

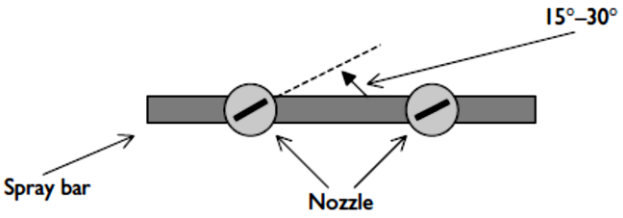

Figure 9.5 Spray nozzle angle.

Plate 9.29 Aggregate spreader.