State of Illinois
Illinois Department of Transportation

Seal Coats

(Oil & Chipping)

July 2017

ILLINOIS TECHNOLOGY TRANSFER CENTER

Illinois Department of Transportation

Printed by authority of the State of Illinois, 0100-17, 07/17, 500

Seal Coats (Oil & Chipping)

Prepared and Published by
Illinois Department of Transportation
Bureau of Local Roads & Streets

Springfield, IL

July 1, 2017

Course and Manual Outline

- Seal Coats – Chip Seal – Oil & Chipping

- Calculations of Quantities
  - Determining Application rates
  - Verifying Actual Quantities

- Materials
  - Aggregates
    - Cover Coat
    - Seal Coat
    - Blotters
  - Bituminous Materials
    - Prime Coat
    - Cover Coat
    - Seal Coat
  - Selection of Materials

- Equipment
  - Mechanical Sweeper
  - Heating Equipment
  - Pressure Distributor
  - Aggregate Spreader
  - Pneumatic Tired Roller

- Construction
  - Surface Preparation
    - Cleaning and Sweeping
    - Filling of Cracks, Pot Holes, and Ruts
    - Excessive Crown
  - Application of the Bituminous Material
  - Application of the Aggregate
  - Rolling
  - Sweeping

- Potential Problems and Solutions
  - Streaked Appearance
  - Bleeding or Flushing
  - Loss of Aggregate
  - Utilities in the Pavement
  - Seal Coating a Cul-de-sac

- Appendix A – Specifications

- Appendix B – References

DOCUMENT CONTROL AND REVISION HISTORY

The Seal Coats (Oil and Chipping) is reviewed after the general township election every four years. Changes to this manual are approved by the Bureau of Local Roads & Streets, Illinois Association of County Engineers, and the Township Officials of Illinois.

Distribution

This manual is available in the Illinois Technology Transfer Center's library as a Portable Document Format (PDF) on the Center's web site and as a hard copy. Hard copies are also provided to the Illinois Association of County Engineers and the Township Officials of Illinois for highway commissioner training.

Revision History

The Bureau of Local Roads & Streets maintains archived copies of the manual since 2004.

Revision Date	Description	Approval
July 1, 2017	Updated Changes in Policy and Statute	Barry Kent

Seal Coats

What are Seal Coats?

Seal coats are normally a very economical means of:

- ✓ Establishing an all weather surface
  - Requiring less maintenance
  - Dust free
- ✓ Maintaining an existing pavement structure in its present condition
- ✓ Change the texture of the roadway
  - Providing better skid resistance
  - Improve ride ability
  - Provide an uniform appearance
- ✓ Change the color
  - Provide contrast between the driving surface and shoulders
  - Improve the reflection of light
- ✓ Provide additional strength to the pavement structure
- ✓ Provide a barrier to keep water out of the base and sub-grade
- ✓ Correct other pavement problems
  - Waterproof open graded pavements
  - Enrich the asphalt for older pavements
  - Improve minor dips or bumps
  - Sealing of cracks

Types of Seal Coats

- ✓ **Fog Seal**

  Is an application of a dilute emulsion without an aggregate cover. Its purpose is to seal and enrich an under-asphalted surface or to tighten and waterproof an open texture pavement. Fog seals can also be used as pre-seals.

  Generally a Cationic Slow Seal (CSS-1) or CSS-1h emulsion is diluted up to 50/50 with water. The CSS-1 can be diluted by either adding the water to the emulsion or the emulsion to the water. The former method usually generates more foam, depending on the drop from the fill stem and the water pressure. It is applied at 0.10 to 0.15 gallons of dilution per square yard. (Application can vary depending on pavement texture, local conditions, and traffic.) It is desirable to keep traffic off the fog seal until the emulsion cures (turns black). However traffic can use it immediately but at a reduced speed to prevent skidding and/or splashing on the cars. The skid resistance of the pavement may be reduced until traffic wears some of the asphalt from the surface.

- ✓ **Construction Seal (Fog Seal)**

  It is an application of a dilute emulsion, usually the same material used for the tack coat. It is to enrich or tighten a new asphalt concrete surface to provide resistance to the entrance of moisture and/or to prevent raveling under traffic. This treatment is particularly helpful with late season paving.

  The most satisfactory method is to apply the same product used for the tack coat to the new asphalt concrete immediately following the final rolling while the pavement is still warm. The emulsion (a 50/50 dilution) should be applied at a rate of 0.05 to 0.12 gallons of the dilution per square yard. (Application can vary depending on pavement texture, local conditions and traffic.)

- ✓ **Sand Seal**

  Is an application of an asphalt emulsion followed by a sand cover aggregate. This sand seal is intended to be used on pavements that have lost some of their matrix, and it is desirable for tightening the pavement texture and reducing raveling.

  Either a Cationic Rapid Set (CRS-1) or CSS-1 can be used. The CSS-1 generally is used in a dilute form (up to 50/50 dilution with water.) The rate of application varies with the pavement texture from 0.10 to 0.20 gallons per square yard. (Application can vary depending on local conditions and traffic.) A variety of sands can be used. Preferably the sand should be 3/8 inch or smaller, clean, and easy to handle. The sand can be applied immediately for maximum stick. However if the emulsion is allowed to break (turn black) on the top of the rock in the pavement, and then the sand is applied, the sand is held only in the pores of the pavement. With this method, the resulting surface is similar to the original texture of the asphalt concrete. Pneumatic tire rolling is desirable but not entirely necessary.

- ✓ **Slurry Seal**

  Is a mixture of specially graded aggregate and an asphalt emulsion. It is applied with a squeegee device. A slurry will seal an existing pavement and produce some minor leveling without the inconvenience of loose cover stone. It can also be used for mass crack filling, to improve skid resistance, to enhance appearance, and to reduce studded tire wear. A slurry made with a coal tar emulsion can protect the pavement in parking areas from damages by petroleum spills and drips.

Aggregates are generally selected using the International Slurry Seal Association (ISSA) grading specification (below). The largest aggregate varies from 1/4 inch to 3/8 inch, depending on the application. Aggregates, which are entirely manufactured, seem to give a better end product and a more durable slurry seal. The aggregate is mixed with a CSS-1, CSS-1h or Cationic Quick Set (CQS-1h) asphalt emulsion. The percent of emulsion is determined by specifications and tests set forth by the ISSA. Slurries are produced in transit mix trucks or specially designed slurry seal equipment and are laid through a drag box with a rubber squeegee strike off. Traffic must be kept off the slurry until it is cured.

- ✓ **Cape Seal**

  A cape seal is a chip seal topped with a slurry seal. A cape seal produces a seal with no loose cover stone. The maximum size of a chip used for the seal coat will establish the depth of the mat. This seal may be the best suited for roads with high traffic volumes.

  A chip seal is laid in the conventional manner. After the chip seal has cured, the loose cover stone is removed. Then the slurry is applied over the seal to fill the voids between the cover stones.

- ✓ **Chip Seal**

  A chip seal is an application of asphalt followed with an aggregate cover. A chip seal is constructed to produce an initial pavement or maintain an existing asphalt pavement.

  The technique of constructing a chip seal and its success are influenced by a number of factors.

  - The weather.
  - The surface on which a chip seal is laid.
  - The grade of asphalt used.
  - The method of storing and handling the asphalt.
  - The type and size of rock used as cover aggregate and the dust and moisture on the stone.
  - The application rate of the asphalt and the rock.
  - The adjustment and operation of the equipment for applying the asphalt and rock.
  - The coordination of the operation.
  - The rolling.
  - The traffic control during and after the seal coat is laid.
  - The brooming.
  - The post-seal inspection and the application of a fog seal, if necessary.

Oil & Chipping or Chip Seal is what will be discussed for the remainder of this manual, however; many of the items to discussed will apply to the other types of seal coats

Calculations of Quantities

How much oil and chips is needed?

- ✓ **Basis of Payment?**

  CL 2017-14 allows changing the basis of payment from Ton to Gallon for Bituminous Seal Coats. LR 403-4 can be inserted into the proposal to change the basis of payment from Ton to Gallon.

- ✓ **How much road is there?**

  Quantities are normally based on square yardage to be covered, therefore; it most be known which roads will be seal.

  Once the roads are determined, the width and lengths need to be measured. The more accurate the measurements are, the more accurate the contractor / vendor will be in determining their bid prices. Items often considered by a contractor in their bid, along with material, labor, and equipment costs are:

  - Is it just a distributor load or tanker(s) of oil?
  - Should the aggregate be hauled in and stockpiled prior to the seal coating? Or can the aggregate be brought in during the seal coating operation?
  - Is it a partial day job or several days to complete?

  If the quantities are strictly a guess and are way off, this could affect the bid price or the operations, especially if the contractor needs to bring in additional oil or aggregate to complete the seal coat.

- ✓ **How accurate does it really need to be?**

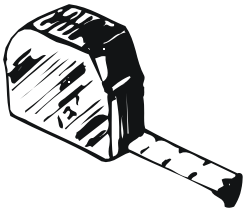
  The more accurate the measurements are, the more time that will involved in measuring. But once a road is measured, it should not have to be re-measured, unless there are changes made to the road. Measurements can be based on scaling off a map or existing plans or actual field measurements.

Methods for scaling off of a map or existing plans can be done with:

- The scale on the map
- Ruler
- Engineering scale
- Planwheel

All of these provide certain pros and cons. The larger the scale on the map and the more accurate the scale is on the measuring device the more accurate the quantities. Field measurement will still need to be completed to determine the width.

Methods for field measurements can be done using:



- Pacing or stepping off.
- Measuring tape.
- Measuring wheel.
- Odometer of a vehicle.
- Electronic Distance Measuring (EDM) device.

All of these once again provide certain pros and cons. For measuring within a municipality, lengths should be measured with a measuring wheel. For rural area an odometer will usual suffice unless it's a short isolated location. For widths a measuring tape should be used, with measurements taken at intervals to accurately determine the width of the roadway.

Example:

If the road is 1 mile (5,280 feet) in length and 22 feet wide the total area would be:

(5,280 ft x 22 ft) / 9 ft^2 / yd^2 = **12,907 yd^2**

Now, if the length was off by 0.1 miles (528 feet) and the width was off by 1 foot this would give a total area of:

(4,752 ft x 21 ft) / 9 ft^2 / yd^2 = **11,088 yd^2**

or

(5,808 ft x 23 ft) / 9 ft^2 / yd^2 = **14,843 yd^2**

This would represent an error of approximately **15%**, thus causing the contractor to being short of materials or having an excess.

What application rate should be used?

- ✓ Bituminous material, the typical application rates will be between 0.20 to 0.50 gallons / yd^2. This amount of bituminous material is dependant on various factors:
    - Type of bituminous material.
    - Existing surface.
        - Surfaces which are bleeding may require less.
    - Amount of traffic.
        - With higher traffic volumes will typically require less.
    - Type of aggregate.
- ✓ Aggregates, the typical application rate will be between 15 to 25 # / yd^2. The amount of aggregate is usually dependant on the specific gravity of the aggregate.

Verifying the application rate and actual quantity used

There are a couple of ways to verify the application rate of the oil and aggregate being used. The first method is based on calculations:

Example:

If the contractor is hauling 15 tons per truck and is spreading 11 feet wide (based on measurements) and is able to travel a distance of 1,000 feet with aggregate from one truck:

(*1,000* ft x *11* ft) / 9 ft^2 / yd^2 = **1,222 yd^2**
(*15* tons x 2,000 # / ton) = **30,000 #**

30,000 # / 1,222 yd^2 = **24.5 # / yd^2**

Therefore; the contractor is applying the aggregate at a rate of 24.5 # / yd^2. If in this same 1,000 distance the contractor applied 350 gallons of bituminous material based on the gages:

350 gal / 1,222 yd^2 = **0.286 gal / yd^2**

Therefore; the contractor is applying the bituminous material at a rate of 0.286 gal / yd^2.

But before making any adjustment to the rates, the actual product should be viewed to determine if proper embedment and proper covering is being achieved.

The other method is based on taking an in place sampling and weighing this. For aggregate a 3' x 3' tarp is placed on the road (no oil in place), the chip spreader then travels across the tarp area. The aggregate on the tarp is then placed in a container and weighed, subtracting the weight of the container.

Here one foot strips are used to collect the aggregate.

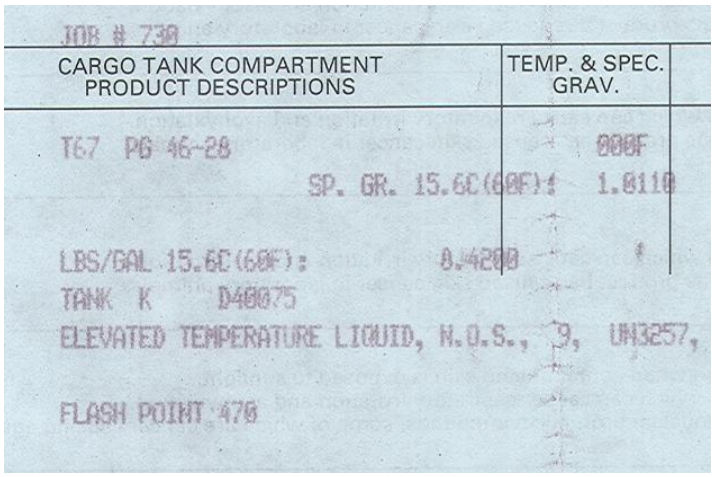
The aggregate is then weighed.

For bituminous material the same is done, normally a piece of felt paper (3' x 3') is used, after the distributor passes over, the bituminous material and paper will be weighed (be sure to weigh the paper before hand).

Example:

If the weight of the bituminous material collected is 2.413 pounds, after subtracting the weight of the felt paper and the specific weight per the "Bill of Lading" is 8.420 # / gallon, then:

2.413 # / *8.420* # / gal = 0.287 gal / yd2


JOB # 730

CARGO TANK COMPARTMENT PRODUCT DESCRIPTIONS	TEMP. & SPEC. GRAV.
T67 PG 46-28	000F
SP. GR. 15.6C(60F):	1.0110
LBS/GAL 15.6C(60F):	8.4200
TANK K D40075	
ELEVATED TEMPERATURE LIQUID, N.O.S., 9, UN3257,	
FLASH POINT 476	

Part of the “Bill of Lading” showing the properties.

Materials

Aggregate (Chips)

The characteristic of the aggregate used in seal coats may improve overall performance in certain areas. These characteristic are the **Type of Aggregate**, **Aggregate Quality**, **Aggregate Shape**, and **Aggregate Gradation** (Open Graded, Well Graded, and Dusty Aggregate).

- ✓ **Types of Aggregate**

  The natural and manufactured materials used as coarse aggregate are defined as follows:

  - **Gravel**. Gravel shall be the coarse granular material resulting from the reduction of rock by the action of the elements and having sub angular to rounded surfaces. It may be partially crushed.

  - **Chert Gravel**. Chert gravel shall be the coarse granular material occurring in alluvial deposits resulting from reworking by weathering and erosion of chert bearing geological formations and containing a minimum of 80 percent chert or similar siliceous material.

  - **Crushed Gravel**. Crushed gravel shall be the product resulting from crushing by mechanical means, and shall consist entirely of particles obtained by crushing gravel, all of which before crushing will be retained on a screen with openings equal to or larger than the maximum nominal size of the resulting crushed material.

  - **Pit or Bank Run Gravel**. Pit or bank run gravel shall be a mixture of sand, gravel, silt and clay occurring naturally in a deposit, which is of such quality that it may be used with only minor processing.

  - **Novaculite Gravel**. Novaculite gravel shall be material occurring in natural deposits, composed of angular particles of siliceous origin and mixed with ferruginous clay.

- **Crushed Stone**. Crushed stone shall be the angular fragments resulting from crushing by mechanical means the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar phanerocrystalline igneous rocks, limestone, dolomite, sandstone, or massive metamorphic quartzite, or similar rocks.

- **Wet Bottom Boiler Slag**. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

- **Crushed Slag**. Crushed slag shall be the graded product resulting from the processing of air cooled blast furnace slag. Air cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumina-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. It shall be air cooled and shall have a compact weight of not less than 70 lb/cu ft.

- **Crushed Sandstone**. Crushed sandstone shall be the angular fragments resulting from crushing, by mechanical means, a cemented sand composed predominantly of quartz grains.

- **Crushed Concrete**. Crushed concrete shall be the angular fragments resulting from crushing portland cement concrete by mechanical means.

- **Chats**. Chats shall be the tailings resulting from the separation of metals from the rocks in which they occur.

- **Crushed Steel Slag**. Crushed steel slag shall be the graded product resulting from the processing of steel slag. Steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen or electric furnace.

- **Crushed Copper Slag**. Crushed copper slag shall be the graded product resulting from the processing of copper slag. Copper slag shall be the nonmetallic product developed in a molten condition simultaneously with copper in a smelter.

✓ **Aggregate Quality**

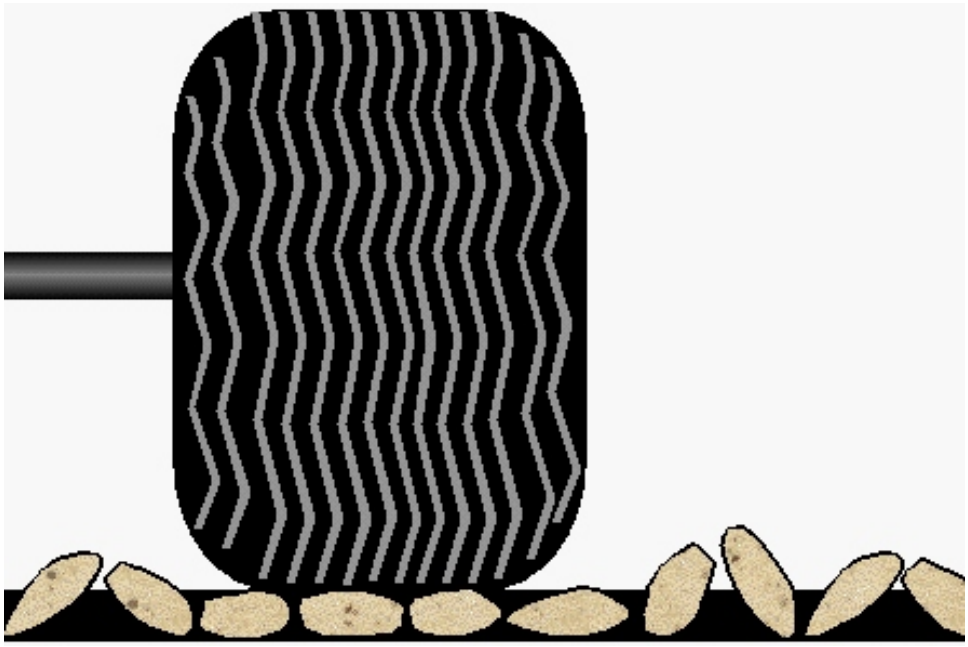
The quality (hardness) of an aggregate will determine how it will resist further crushing and degradation of the aggregate.

- "Class A" aggregates provide the best quality, but the price makes it uneconomical for seal coats.
- "Class B" aggregates provide a better quality, yet still is not the most economic for seal coats.
- "Class C" aggregates will typically hold up to further crushing, but still degrades, yet the price makes it economical to use for seal coats.
- "Class D" aggregates will crush easier under traffic and degrade more rapidly, but is usually least expensive.

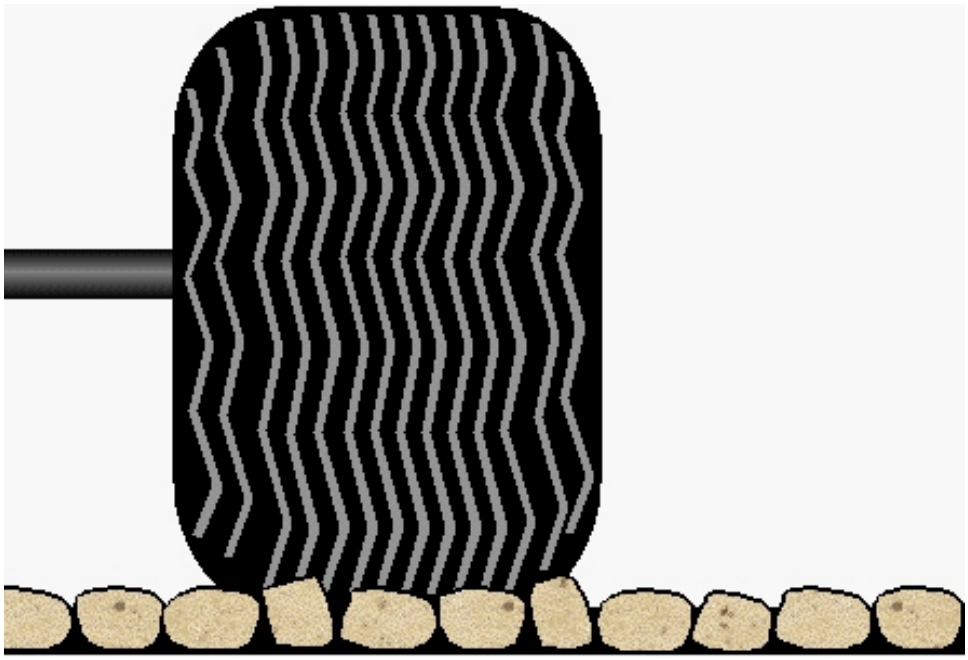
COARSE AGGREGATE QUALITY				
QUALITY TEST	CLASS			
	A	B	C	D
Na_2SO_4 Soundness 5 Cycle, ITP 104 [1/], % Loss max.	15	15	20	25 [2/]
Los Angeles Abrasion, ITP 96, % Loss max.	40 [3/]	40 [4/]	40 [5/]	45
Minus No. 200 (75 µm) Sieve Material, ITP 11	1.0 [6/]	---	2.5 [7/]	---
Deleterious Materials [10/]				
Shale, % max.	1.0	2.0	4.0 [8/]	---
Clay Lumps, % max.	0.25	0.5	0.5 [8/]	---
Coal & Lignite, % max.	0.25	---	---	---
Soft & Unsound Fragments, % max.	4.0	6.0	8.0 [8/]	---
Other Deleterious, % max.	4.0 [9/]	2.0	2.0 [8/]	---
Total Deleterious, % max.	5.0	6.0	10.0 [8/]	---

- ✓ **Aggregate Shape**

  The ideal shape is a cubical aggregate versus a flat & elongated aggregate. A cubical aggregate will provide for a uniform seal coat height and embedment of the aggregate.



Traffic causes the flat & elongated aggregates to lay down on the flattest side mainly in the wheel paths.



Traffic has little effect on cubical aggregates.

If flat & elongated aggregate must be used, some ways to minimize problems are:

- Calculate the application rate for the oil needed for non-wheel paths and for the wheel path areas and use an average. This will minimize the amount of oil which will cover the aggregate laying flat in the wheel paths and still provide enough oil to hold the aggregate in the elongated position in place.
- Apply 5 to 10% more aggregate to the wheel paths by increasing the gate openings on the spreader in these areas.
- Modify the spray bar in these areas by placing a smaller nozzle.
- High volume roads, flat & elongated aggregates should not be used.

This is a Flakiness Index Plate for testing aggregates for flatness. The lower the Flakiness Index, the more cubical the aggregate is.

An aggregate which is angular in shape is less likely to move versus a rounded aggregate. The angular aggregates tend to lock together better and provides more surface area to bind with the oil.

If a rounded aggregate must be used, some ways to minimize problems are:

- Use an open graded aggregate.
- Extra care should be taken to ensure proper embedment.
- High volume roads, consider a double seal coat with the top layer of aggregate smaller than the bottom layer by about 50%. The smaller aggregate will help lock in the larger ones and are less likely to cause damage to windshields or head lights.

Cross section of a double seal coat.

✓ Aggregate Gradation

The gradation of the aggregate will greatly affect the seal coat. Gradation is determined by the amount of aggregate passing through the various size of openings. This is then compared to known charts developed to determine the best gradation for a particular operations.

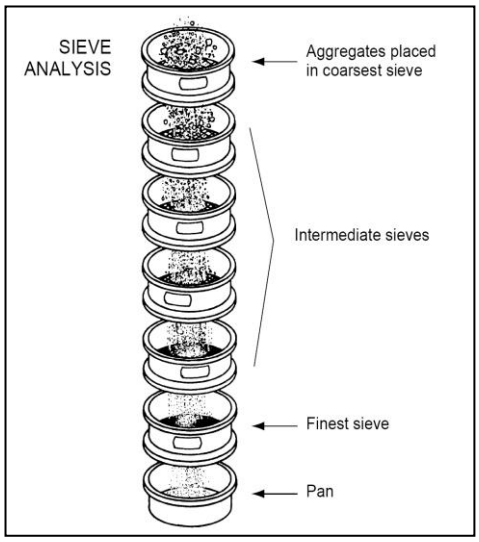


Photo of an actual sieve (above).
Diagram of a Sieve Analysis (left).

Grad No.	COARSE AGGREGATE GRADATIONS Sieve Size and Percent Passing												
	3 in.	2 1/2 in.	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 200 [1/]
CA 1	100	95±5	60±15	15±15	3±3								
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4
CA 3		100	93±7	55±20	8±8		3±3						
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4
CA 5				97±3 [2/]	40±25		5±5		3±3				
CA 6				100	95±5		75±15		43±13		25±15		8±4
CA 7				100	95±5		45±15 [7/]		5±5				
CA 8				100	97±3	85±10	55±10		10±5		3±3 [3/]		
CA 9				100	97±3		60±15		30±15		10±10		6±6
CA 10					100	95±5	80±15		50±10		30±15		9±4
CA 11					100	92±8	45±15 [4/7/]		6±6		3±3 [3/5/]		
CA 12						100	95±5	85±10	60±10		35±10		9±4
● CA 13						100	97±3	80±10	30±15		3±3 [3/]		
● CA 14							90±10 [8/]	45±20	3±3				
● CA 15							100	75±15	7±7		2±2		
● CA 16							100	97±3	30±15		2±2 [3/]		
CA 17	100								65±20		45±20	20±10	10±5
CA 18	100				95±5				75±25		55±25	10±10	2±2
CA 19	100				95±5				60±15		40±15	20±10	10±5
CA 20							100	92±8	20±10	5±5	3±3		

Illinois Department of Transportation
– Standard Specification for Road and Bridge Construction (Adopted January 1, 2002)

● Denotes the gradations typically used for seal coats in Illinois. (CA 13, CA 14, CA 15, and CA 16)

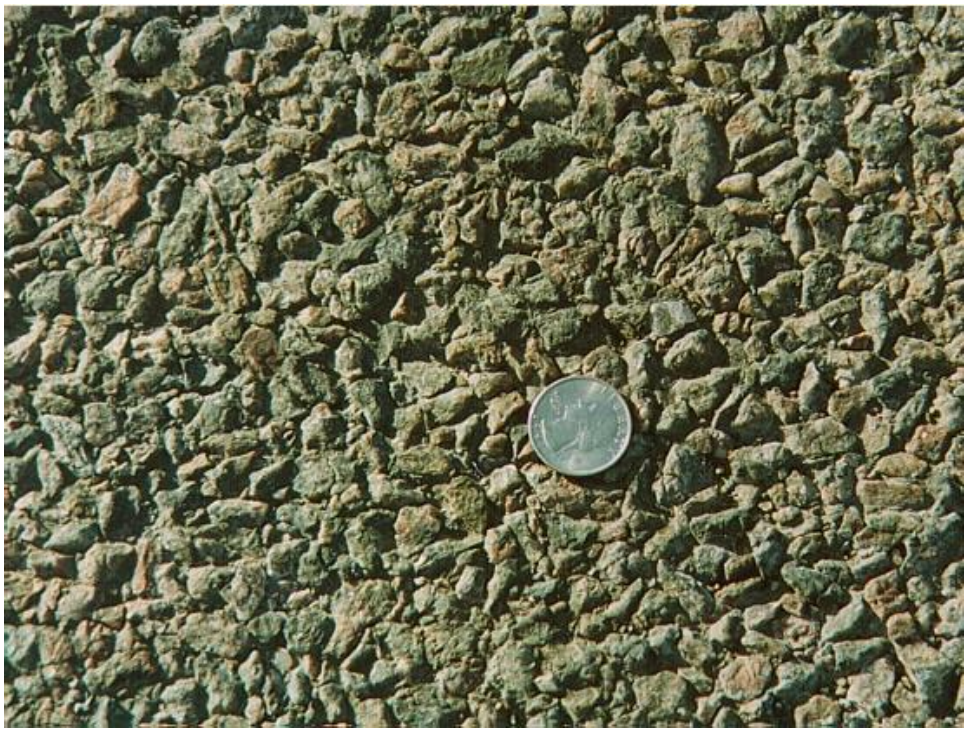
Open Graded Aggregate

Cross section of an open graded seal coat aggregate.

An open graded aggregate is an ideal aggregate to use for seal coats. An open graded aggregate is where almost all of the aggregate is retained on two consecutive sieves.

An open graded aggregate will improve:

- The skid resistance, since the tires will be in firm contact with more of the aggregates.
- Proper embedment will occur easier, with the ability to minimize bleeding of the oil.
- Water will drain off the surface quicker and more positively, through the open channels between the individual chips.



An open graded seal coat aggregate.

Well Graded Aggregate

Cross section of a well graded seal coat aggregate.

The more graded an aggregate is the less desirable it is for seal coats. They have lower voids for the oil to occupy, which will normally result in bleeding.

A well graded aggregate will typical encounter these problems:

- Vehicle tires make less firm contact with the aggregate reducing skid resistance.
- Larger size aggregates will stick above the average thickness making them more prone to removal from vehicles or snow plows.
- Smaller size aggregates will be completely surrounded by the oil, thus causing bleeding.

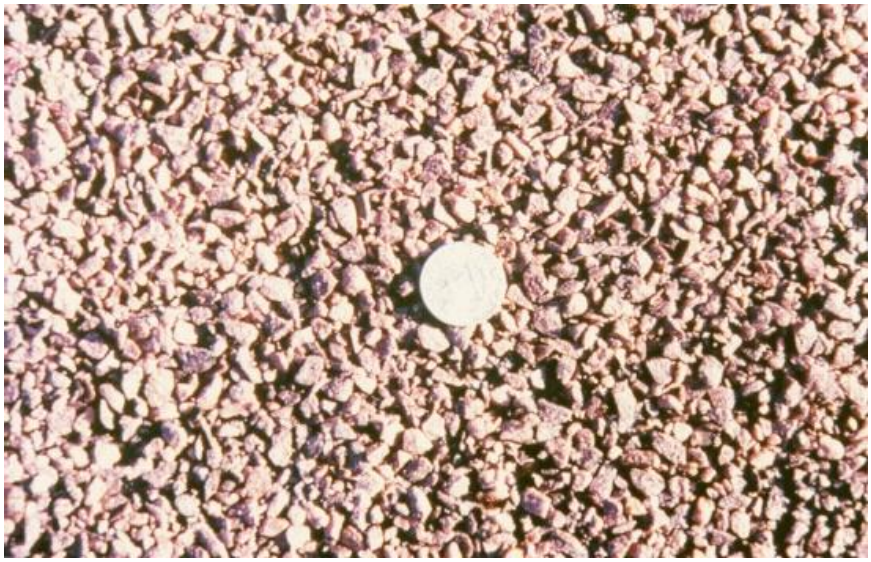
A well graded seal coat aggregate.

Dusty Aggregate

Aggregate with a large amount of dust, passing the No. 200 Sieve, should not be used in seal coats. This dust will coat the outside of the larger aggregates making them less likely to bind with the oil.

If a dusty aggregate must be used, various ways to minimize problems are:

- Wash the aggregate.
- Use a high float emulsion, the wetting agent will help cut through the dust.
- Pre-coat the aggregate, with a light coating of asphalt.



Before sweeping.

After sweeping – notice the loss of the larger aggregate.

- ✓ **Cover Coat**

  The aggregate for a cover coat is generally a larger aggregate than for a seal coat. The gradation is normally a CA 13 or CA 14. It is used in the construction of A-2 and A-3 Bituminous Surface Treatment and is capped off with a seal coat.

- ✓ **Seal Coat**

  The aggregate for a seal coat is generally a smaller aggregate than for a cover coat. The gradation is normally a CA 15 or CA 16. It is used in the construction of A-1, A-2, and A-3 Bituminous Surface Treatment as the top lift.

- ✓ **Blotters**

  The aggregate used for blotting purposes is generally the a medium or a coarse sand. This is used to minimize the amount of oil picked up by vehicle tires. The size to use may depend on the severity of the bleeding.

The blotter material will cover up oil, which has bled through.

- ✓ **General Notes on Aggregates**

  The aggregate should contain no free moisture. If it is damp, traffic should not be allowed to run on it until it has time to dry.

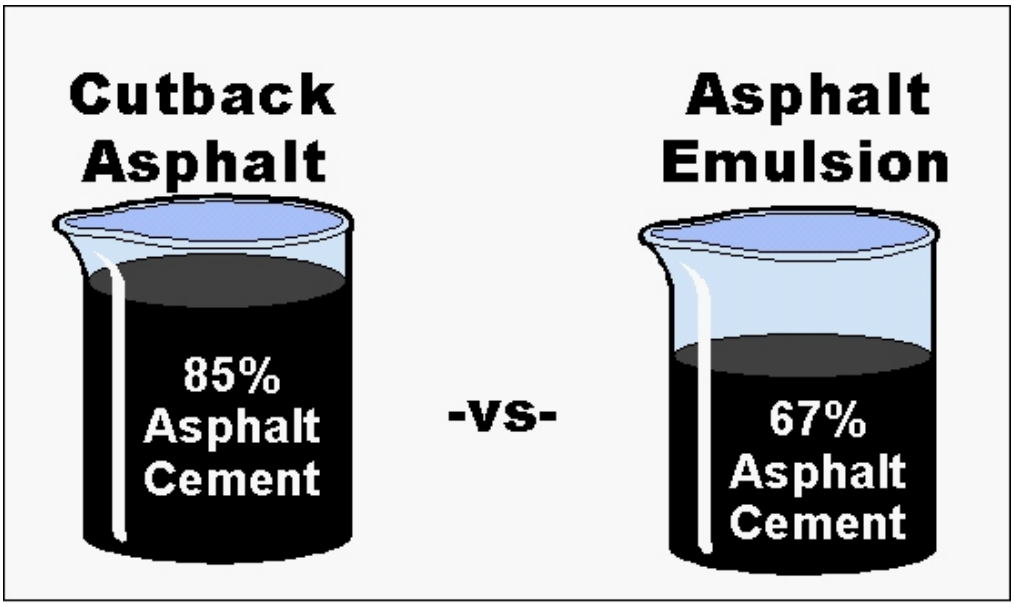
  The application rate for aggregate should be between 15 to 25 pounds per square yard. Adjustments to the application rate should be considered depending on the specific gravity of some of the manufactured aggregates.

Bituminous Materials (Oil)

The characteristic of the bituminous material used in seal coats may improve overall performance in certain areas. These characteristic are the **Type of Bituminous Material**, **Setting Speed, Viscosity,** and **Penetration of Residue**.

- ✓ **Types of Bituminous Material**

  There are three basic types of bituminous material used in seal coats. They are cutback asphalts, asphalt emulsions, and road oils within these groups are various classifications. One advantage cutbacks have over emulsions is a much higher residual asphalt percent, typically over 80 percent. This compares with just over 65 percent for asphalt emulsions. The result is more asphalt cement left on the roadway after curing, for the same volume of binder applied.



Amount of residue asphalt.

Cutback Asphalts

Also known as liquid asphalts are asphalts that are dissolved in a petroleum solvent (cutter). Typical solvents include naptha (gasoline) and kerosene. The type of solvent controls the curing time of the cutback and thus when it will obtain its ultimate strength. Rapid curing cutbacks use naptha (gasoline) while medium curing cutbacks use kerosene. The amount of cutter affects the viscosity of the cutback asphalt. The higher the cutter content, the lower the viscosity and the more fluid it will be. The use of cutbacks has declined rapidly over the years due to concerns over pollution and health risks as the solvents evaporate into the atmosphere.

Cutbacks are divided up into three classification, Rapid Curing (RC), Medium Curing (MC), and Slow Curing (SC) depending on the solvent used. A number value (MC-30) is also assigned to these to indicate the viscosity, the lower the number the more fluid the cutback is.

Typical cutback asphalts used in seal coats are:

- MC-30 (Prime Coat)
- SC-250, 800, and 3000 (Cover or Seal Coat)
- MC-250, 800, and 3000 (Cover or Seal Coat)
- RC-250, 800, and 3000 (Cover or Seal Coat)
- PG46-28 and PG52-28 (Cover or Seal Coat)

Asphalt Emulsions

Is a combination molten asphalt blended into fine droplets, surrounded by a chemical solution (emulsifier), and water. The emulsifier provides the stabilization.

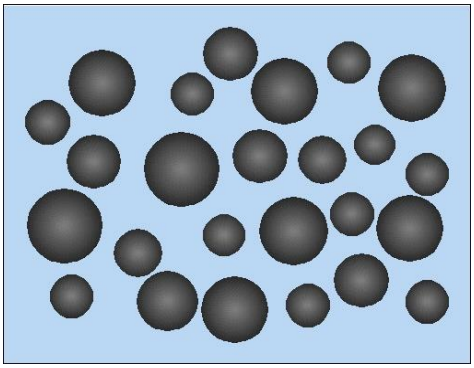
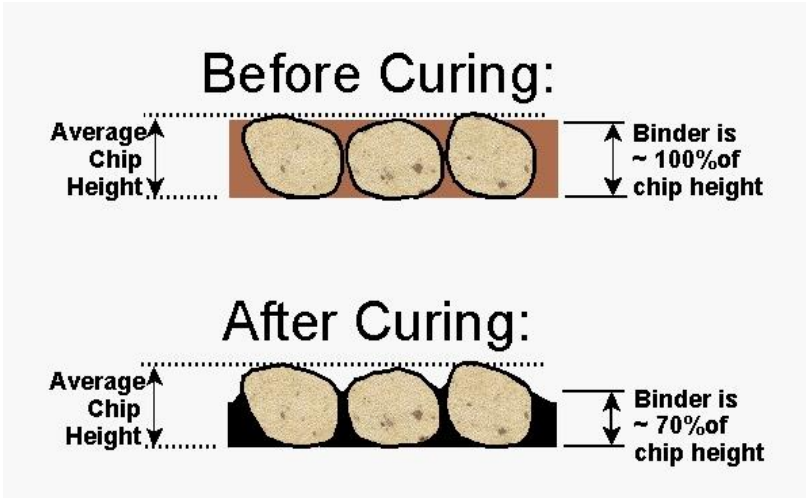


Diagram of an asphalt emulsion.



Once the emulsion has cured about 70% is left of the residual asphalt.

Asphalt emulsions are initially divided into three classifications:

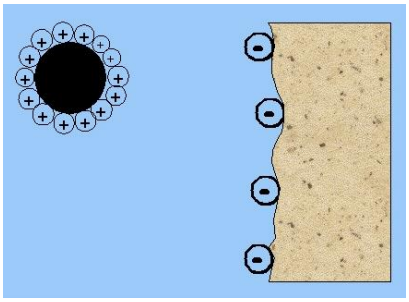
- Cationic, which has a (+) electrical charge
- Anionic, which has a (-) electrical charge
- Non-ionic, which is not used in roadway construction and maintenance, and will not be discussed any further.

Depending on whether a cationic (+) or anionic (-) asphalt emulsion is used, an aggregate with the opposite charge should be used. If the emulsion and the aggregate have the same charge the materials will repel each other and failure of the seal coat will result.

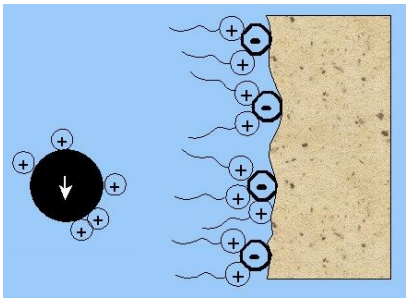
Asphalt emulsions are further classified as Rapid Setting (RS), Medium Setting (MS), and Slow Setting (SS) to denote the speed in which the asphalt particles fall to the bottom as the charge is drawn towards the aggregate. A number value (RS-1 or RS-2) is also assigned to these to indicate the viscosity, the lower the number the more fluid the emulsion is. If it is followed by an “h”, the emulsion has a harder base asphalt.

Cationic Emulsifiers

Are generally the most widely used, since most aggregates have a negative charge. This will cause the asphalt particles to have an electrical bond with the aggregate, thus providing a direct and a very rapid reaction. After the chemical break is complete, the water still needs to be completely evaporated for the residual asphalt to obtain full strength.



Cationic emulsion before breaking.



Cationic emulsion during breaking.

Anionic Emulsifiers

Are generally not as widely used. The asphalt particles repel from the aggregate, but will cause the to be forced together. This starts to occur as the emulsion begins to break and the water evaporates away.

Cationic Emulsions versus Anionic Emulsions

- Less sensitive to the weather.
- Be stabilized easier without increasing break times.
- More critical in handling.
- Closer attention needs to be given in the storage procedures.
- More suitable for aggregates.
- No pre-coating of aggregates is needed, provided the aggregate is clean and dust-free.

High Float Emulsions

Have passed the Float Test (AASHTO T-50 or ASTM D-139) and have a quality imparted by the addition of certain chemicals that permit a thicker asphalt film on the aggregate particles with a minimum probability of drainage. This property allows high-float emulsions to be used with somewhat dusty aggregate with good success.

Typical emulsified asphalts used in seal coats are:

- PEP (Penetrating Emulsified Prime)
- SS-1, SS-1h, MS-2, RS-1,and RS-2
- CSS-1, CSS-1h, CMS-2, CRS-1,and CRS-2
- HFE-90, HFE-150, and HFE-300 (High Float)
- HFRS-2 (High Float and Anionic Emulsion)

Road Oils

Are not as commonly used as cutbacks or asphalt emulsions. They behave similar to cutbacks, but have a much higher flash point, since they are not cut with a solvent.

Typical road oils used in seal coats are:

- E-2 (Light)
- E-3 (Medium)
- E-4 (Heavy)

The various types of bituminous materials should never be mixed together within the storage tanks, tankers, or distributor.

Selection of Materials

Many factors go into the selection of materials to be used in seal coats. These may include:

- Costs
- Availability
- Workability
- Special equipment
- Material characteristics
- Public complaints

	Pros	Cons
Aggregates		
Crushed Limestone	Cubical and angular in shape.	More dust, unless washed or pre-coated.
• Pre-coated Limestone	Eliminates the dust. Provides more holding power.	Costs $10.00 or more per ton.
Gravel	Less dust. Costs a few dollars less.	Not angular in shape, easier to dislodge.
• Crushed Gravel	Angular in shape. Less dust.	Only available in the northern half. Costs a few dollars more.
Slag	Very durable. May require less material (Air Cooled Blast Furnace Slag).	Costs a few dollars more. May require more material (Steel Slag).

Bituminous Materials		
Cutbacks	Richer in asphalt, may self heal hairline cracks. Costs more.	Richer in asphalt, may bleed more often. Not as safe to handle.
Emulsions	Will not bleed as often. Costs less. Safer to handle. Cures quicker.	Becomes more brittle, subject to hairline cracks.
Road Oils		

Equipment

Mechanical Sweeper

Sweeping is one of the crucial steps in obtaining a proper seal coat. The first is the cleaning of the existing road to ensure a good bond with the bituminous material. The second is sweeping afterwards to remove only the chips, which are not embedded. There are two different types of power brooms used in seal coating. Seal coats constructed in rural areas typically use front mounted rotary sweepers. For urban areas, pick-up sweepers are normally used.

Rotary sweeper.

Pickup sweeper.

Heating Equipment

The heating equipment needs to have sufficient capacity to heat the bituminous material properly by circulating steam or hot oil through coils of the tank car or storage tank. Tank cars which have defective coils or which are without coils should not be used. The use of any equipment to agitate the bituminous material should not be used if it changes the characteristics of the bituminous material.

Pressure Distributor

Another important pieces of equipment in the seal coat operation is the asphalt distributor. It must be able to apply a uniform layer of asphalt binder at the correct thickness and width. Most distributors now have computerized controls which can regulate the pressure of the material to compensate for the speed of the vehicle. This will result in a constant application rate, regardless of travel speed.

Distributor Truck.

Close-up of the spray nozzles.

Aggregate Spreader

Another important piece of equipment is the aggregate chip spreader. It must be capable of applying a uniform, even layer of aggregate across the entire width during the seal coat operation. A self-propelled chip spreader is desirable. This type of spreader pulls the aggregate trucks as it travels down the road. When the truck is empty, it is released by the spreader and another backs into place. If done properly, minimal interruptions in the seal coating should occur. The most chips spreaders now have computerized controls that allow the gates to open and close hydraulically and to compensate for the speed of the spreader. This result in a constant application rate, regardless of travel speed.

Chip spreader with truck attached.

Hopper of the chip spreader.

Auger moving chips to the gates.

Pneumatic Tired Roller

And yet, another important pieces of equipment are the pneumatic tired rollers. The primary function is to embed the aggregate into the bituminous material and orient the chips on their flat side. It is important to have enough rollers to complete the rolling quickly. The chips need to be embedded into the binder before it “breaks.” Sufficient rollers need to be on the project. It is very important for the rollers to travel slowly and minimize turning, so the chips are correctly embedded and are not dislodged.

Roller ensuring proper embedment.

Tires should be free of asphalt to minimize chips from being dislodged.

Construction

Surface Preparation

Preparation of the surface is key in obtaining a proper seal coat. This does not just include sweeping the road to remove any dirt, debris, etc., but also to repair any failures in the surface or base.

Sweeping the road is essential, besides removing unwanted debris it may uncover other problems not previously seen.

Minor cracks in the pavement may be okay, but if the crack starts approaching the size of the aggregate, then filling of those cracks prior to seal coating should be considered. If there is extensive alligator cracking, then either a slurry seal or scarifying of the road may want to be considered.

Potholes, minor rutting, or isolated base failures should be properly patched or repaired.

Road still needs to be swept to remove debris.

Isolated alligator cracking with minor cracking.

Isolated alligator cracking with major cracking.

Patch on patch on patch, there may be underlying causes in the base.

This appears to be good patch, but should have been extended.

This is an aggregate patch, if it was placed on top of the existing bituminous, it will most likely fail.

Slurry coat being applied to fill in alligator cracks.

Another item which needs to be addressed during surface preparation is an excessive crown. Most seal coats over the years will start to build up more material at the center of the road, then at the edges. This can cause problems for the motorist, such as the desire to drive at a more level position, thus driving down the center of the road. Or during snow and ice, causing vehicles to slip towards the outside of the road or not being able to drive up the steep grade created by excessive crown.

To help eliminate the excessive crown, the road could be scarified and reshaped or the outside edges built up prior to seal coating.

Scarifying and reshaping the road to correct defects, such as excessive crown.

Tilling operation with new aggregate and bituminous material is added.

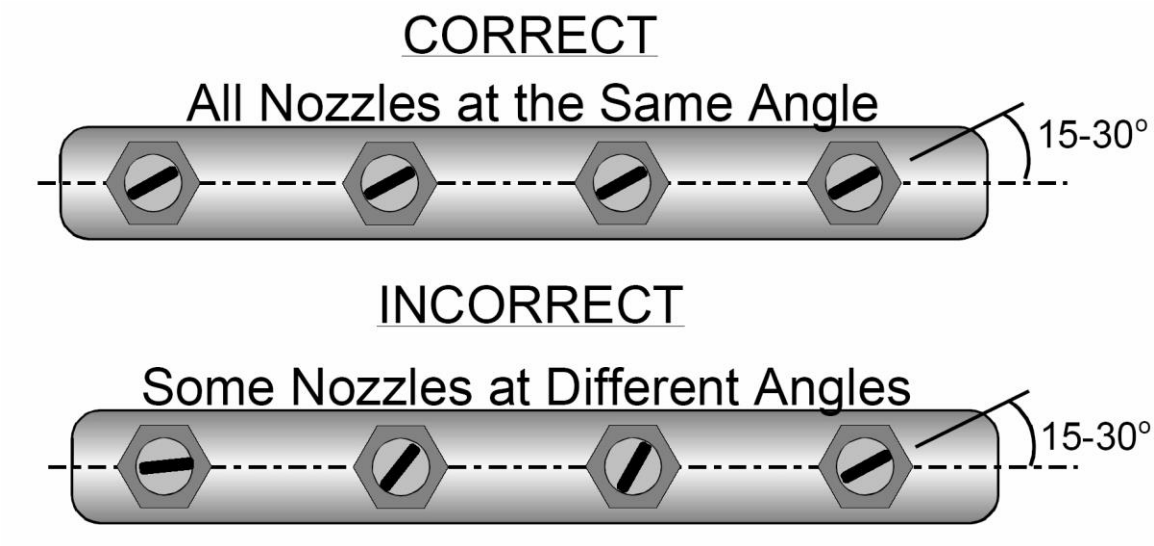
Application of the Bituminous Material

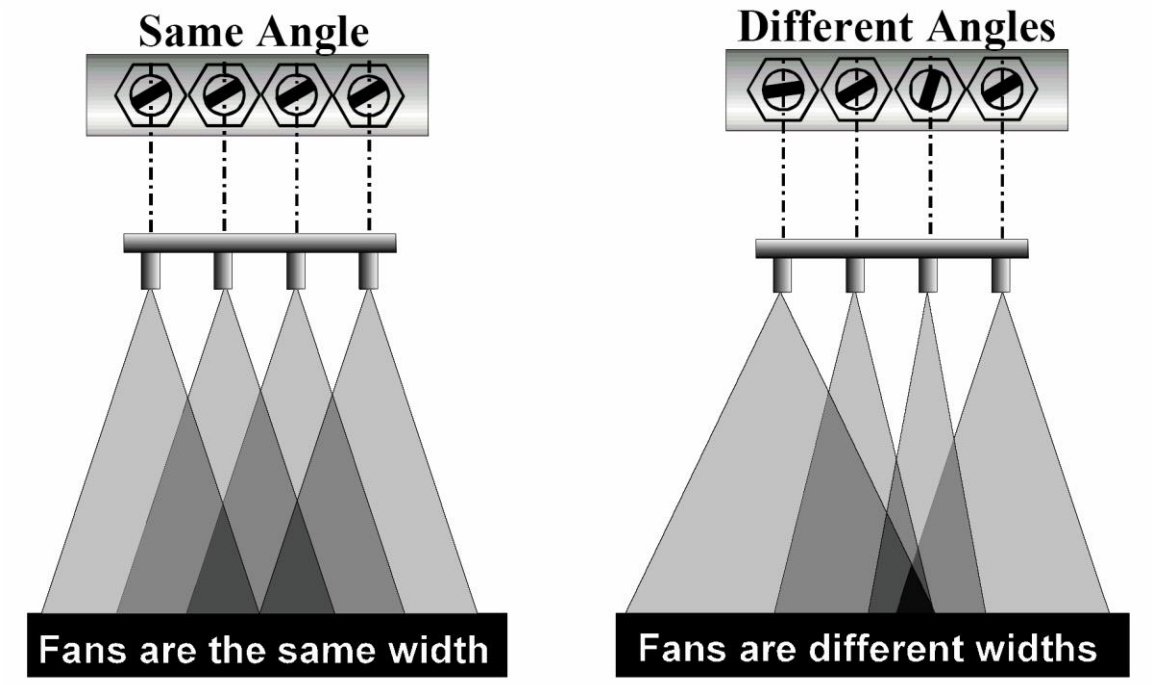
The application of the bituminous material should provide for a uniform depth (application rate) across the width of the sprayers. A hand sprayer should be available for areas which can not be accessed by the distributor. The spray bar should be set to the proper height to avoid thin or thick areas. Heavy paper or similar item should be place across the previous end point to eliminate the build up of material and properly disposed of.

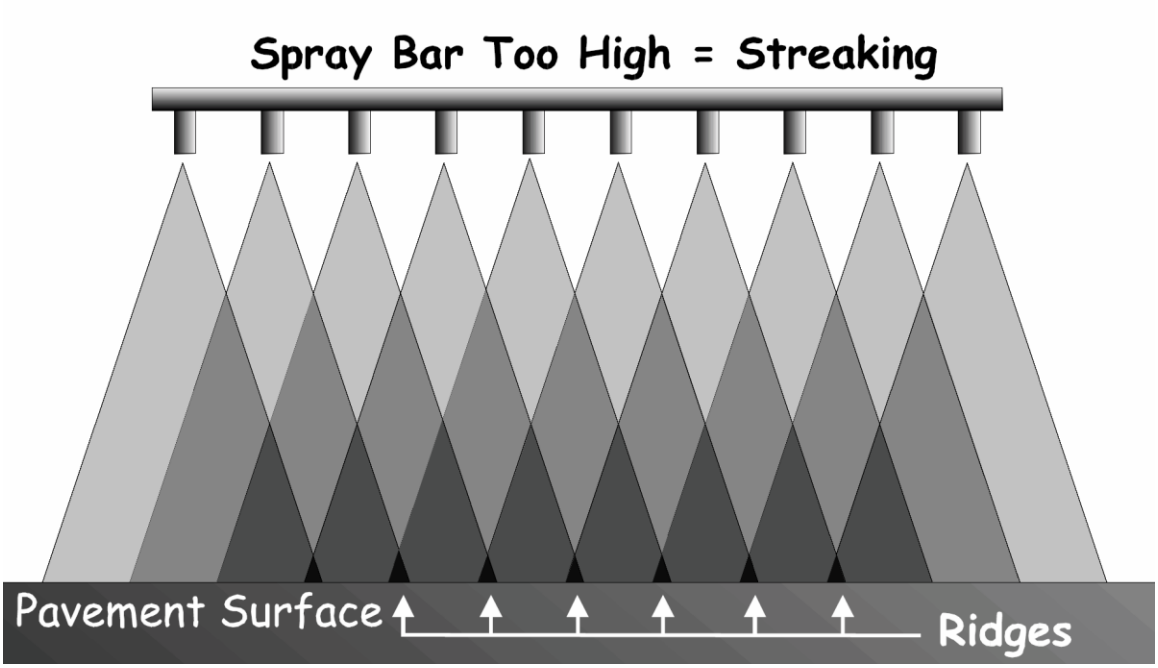
Seal coats should be done between May 1 and October 1. The temperature of the bituminous materials needs to be within specifications for the type of material being used. The temperature in the shade is above 60^{o} F and rain should not be in the local forecast.

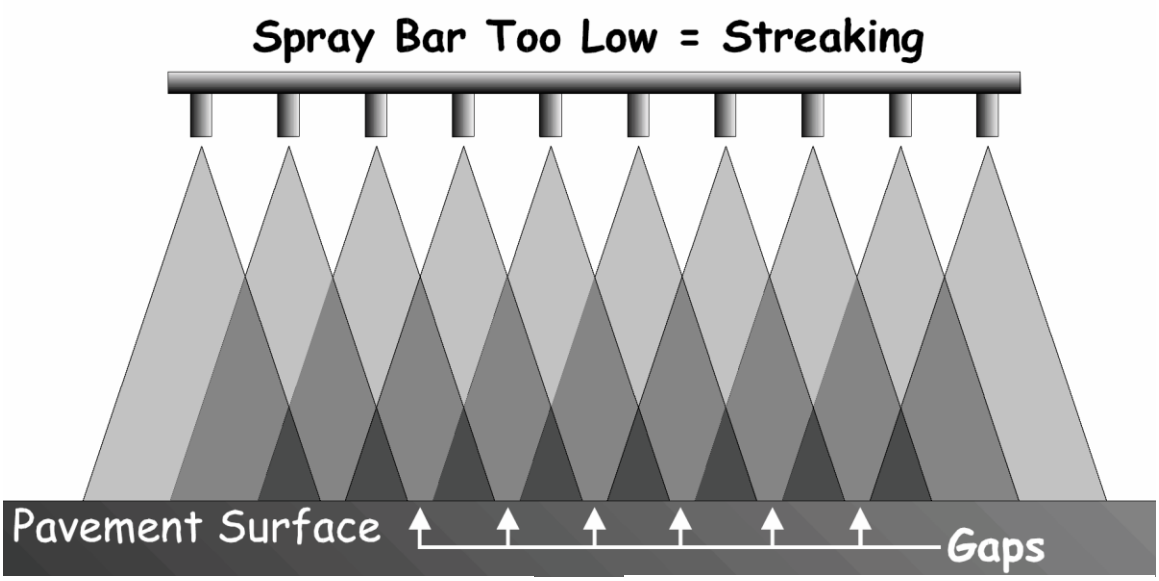
A uniform thickness at the proper application rate is a must for a proper seal coat.

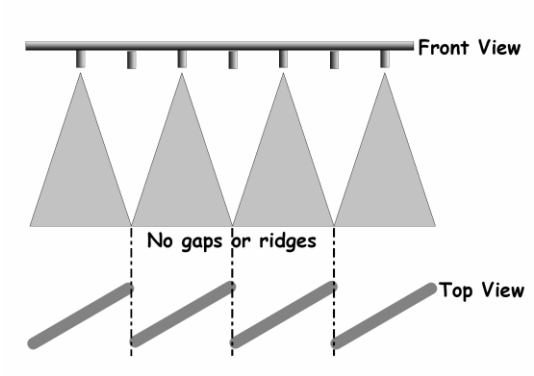
Spray nozzles need to be aligned properly with none of the nozzles plugged with debris. The spray bar needs to be at the proper height. As the seal coat operation proceeds and the distributor empties the spray bar height may need to be readjusted.



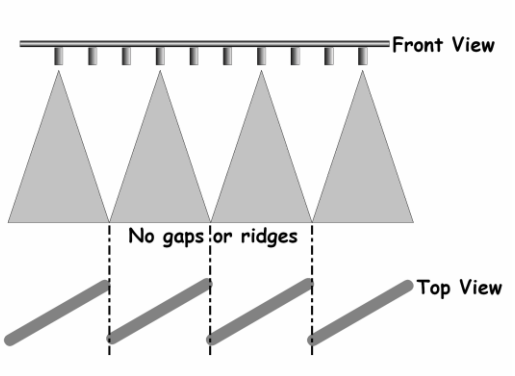








Double Lap Seal.



Triple Lap Seal.

Application of the Aggregate

The application of the aggregate should provide for a uniform depth (application rate) across the width of the gates. The aggregate should contain no free moisture. If aggregate is damp it may be spread but allowed to dry before it is disturbed by traffic. Any ridges created from the spreader needs to be smoothed out with a hand broom. The aggregate needs to be placed on the bituminous material as soon as possible, to avoid the asphalt from breaking prior to the aggregate being placed.

Seal coat operation staying in a close train to avoid the bituminous material from breaking prior to the aggregate being placed or rolled.

Insufficient aggregate.

Excessive aggregate.

A uniform application of the aggregate.

Rolling

Proper rolling will ensure help ensure proper embedment of the aggregate into the bituminous material. Rolling the aggregate prior to the bituminous material is crucial. Rolling needs to start along the edge moving longitudinal and progress towards the centerline. The roller should overlap the previous area by ½ the roller width. The roller needs to minimize turning and maintain a speed as to not displace the aggregate.

Inspection of aggregate embedment, bituminous material should cover approximately 70%.

The use of pneumatic tire rollers is required. Steel rollers will crush the aggregate.

Sweeping

Once all of the solvents or water has evaporated from the bituminous material a final sweeping should be done to remove any loose aggregate. Sweeping should not dislodge any embedded aggregate, if it does the downward pressure of the sweeper should be adjusted.

Potential Problems and Solutions

Streaked Appearance

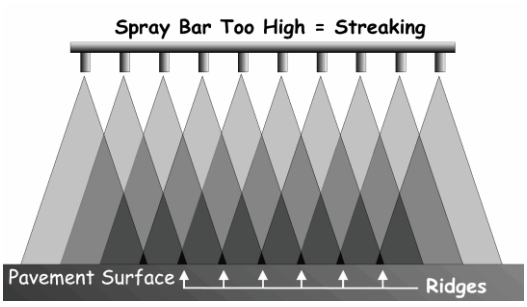
Streaking is identified by longitudinal grooves or ridges in the seal coat surface. Though streaking is primarily a cosmetic problem it is an undesirable one. If the distributor is calibrated properly, streaking can virtually be eliminated. The three most common causes of streaking, in order of occurrence, are:

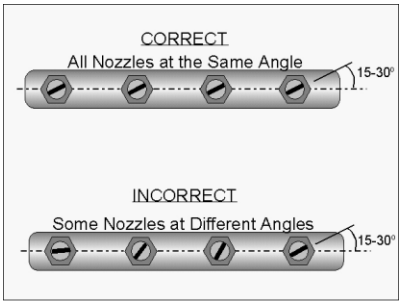
- Incorrect spray bar height.
- Misalignment of the spray nozzles.
- Clogged spray nozzles.

Example of streaking caused by incorrect spray bar height (notice streaks).

Solution

- Check the spray bar height.
- Align the spray nozzles properly.
- Make sure the spray nozzles are not clogged.



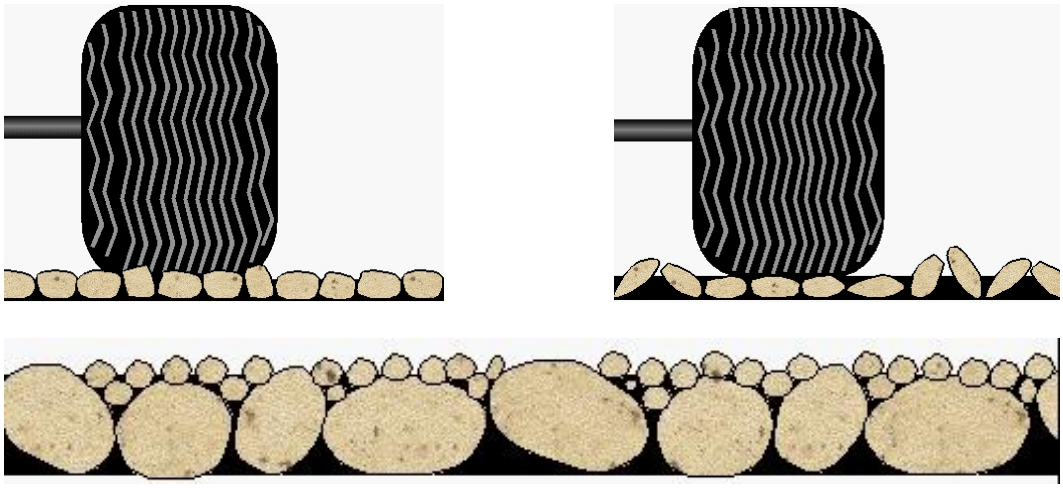


Bleeding or Flushing

Bleeding, also referred to as flushing, is defined as “excess asphalt in the wheel path, or traffic areas.” It is caused by too much asphalt binder for the aggregate. If the binder is applied too thick, it may rise above the top of the aggregate and stick to the construction equipment. More often, the binder is just below the surface of the pavement after curing and is sucked to the top by traffic, particularly on hot summer days.

Solution

- Use cubical aggregate, instead of flat & elongated aggregate.
- Reduce the bituminous material application rate.
- Apply a blotter, to help prevent the aggregate from being dislodged or additional bituminous material from being tracked.



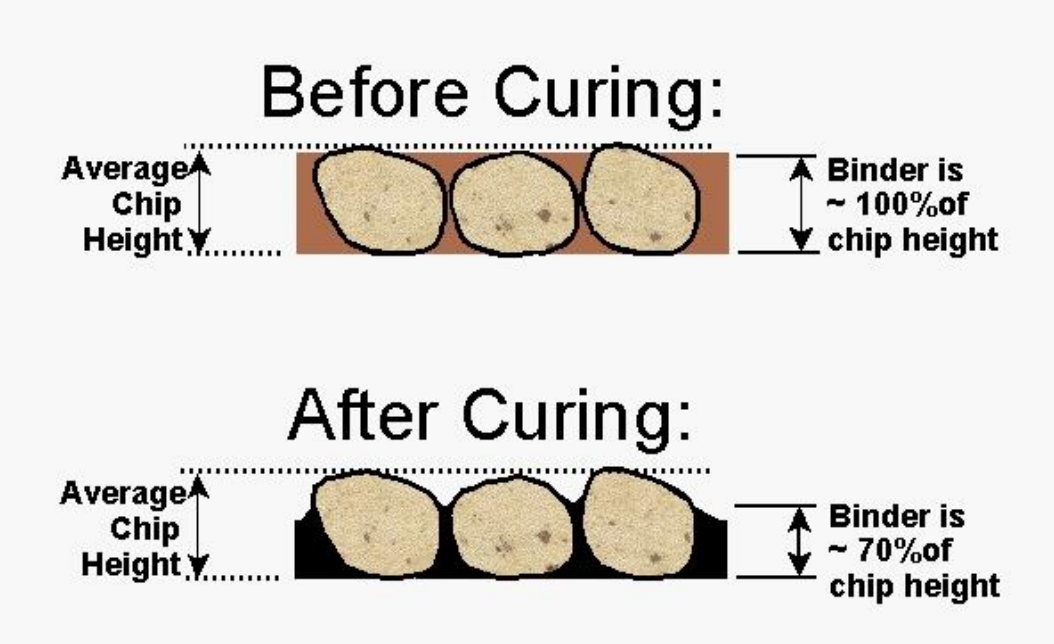
Loss of Aggregate

Perhaps the most common problem, and the least desirable, is the loss of some or all of the aggregate. Possible causes are:

- Insufficient bituminous material
- Poor rolling of longitudinal seam at the centerline
- Allowing the bituminous material to “break” before the aggregate is placed and rolled
- Poor gradation
- Dusty aggregate
- Excessive snow plow down pressure

Solution

- Apply more bituminous material.
- Use proper rolling procedures.
- Apply the aggregate prior to the bituminous material “breaking”.
- Use a open graded, angular, clean, and dust free aggregate.
    - Wash the aggregate.
    - Use a high float emulsion, such as HFRS-2.
    - Pre-coat the aggregate with a bituminous material.
- Adjust snow plowing procedures.



Utilities in the Pavement

When seal coating in urban areas where manholes and water valves are in the street, the bituminous material will stick to these structures unless precautions are taken.

Solution

- Cover the manholes and water valves with a heavy paper and sand, prior to seal coating.

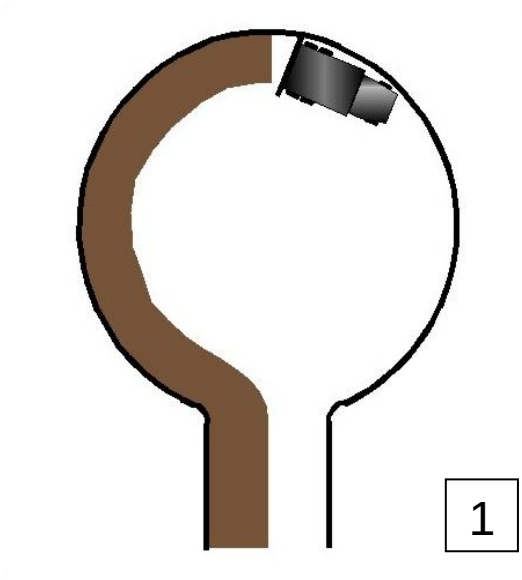
Seal Coating a Cul-de-sac

One of the most common problems encountered when seal coating in urban areas is the loss of aggregate, and subsequent bleeding in cul-de-sacs.

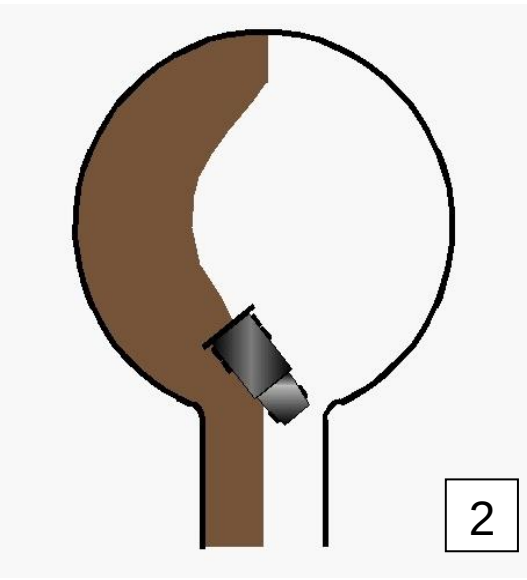
By applying all of the bituminous material at first, before any aggregate, the bituminous material will most likely start to break.

Solution

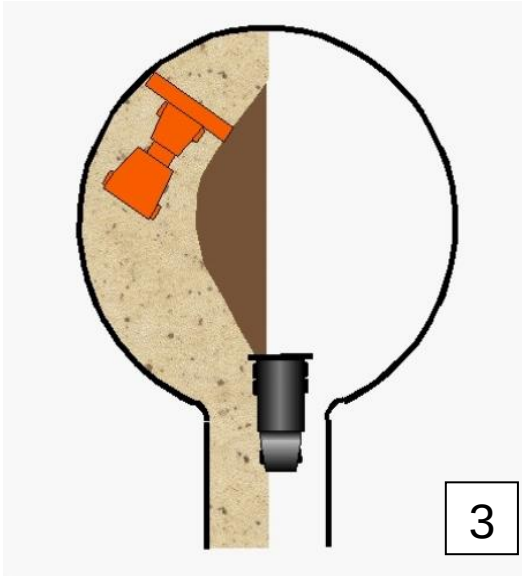
- Proper sequence of operations of a cul-de-sac will help ensure a proper seal coat.



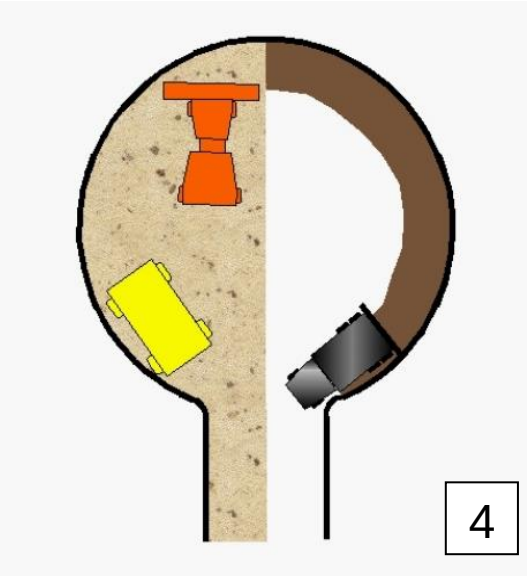
Apply the bituminous oil along one edge for half of the cul-de-sac.



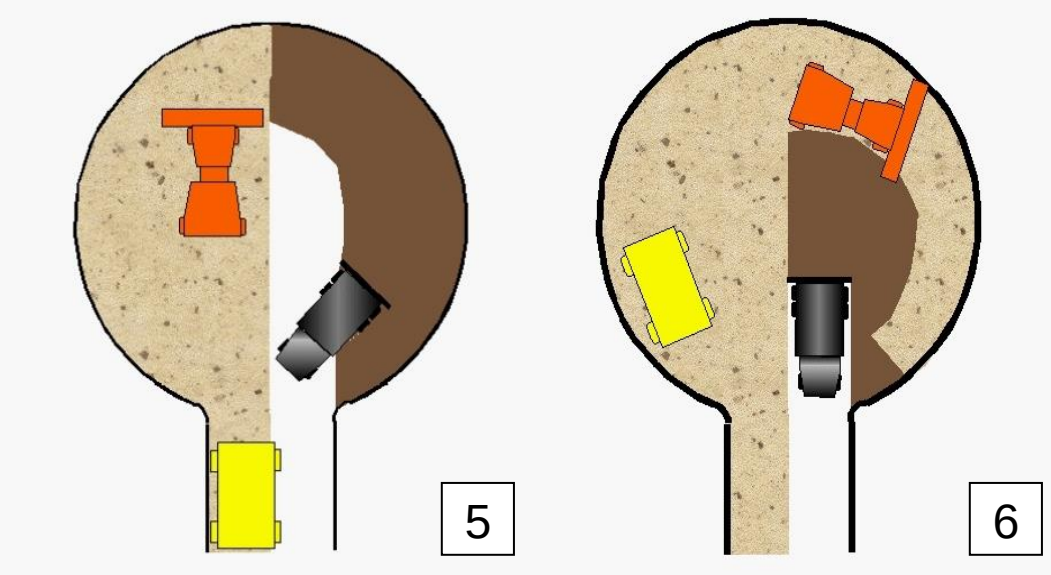
Apply the bituminous material adjacent to the first application.



Begin apply the aggregate to the first and second application of the bituminous materials, as the third application of bituminous material is applied.

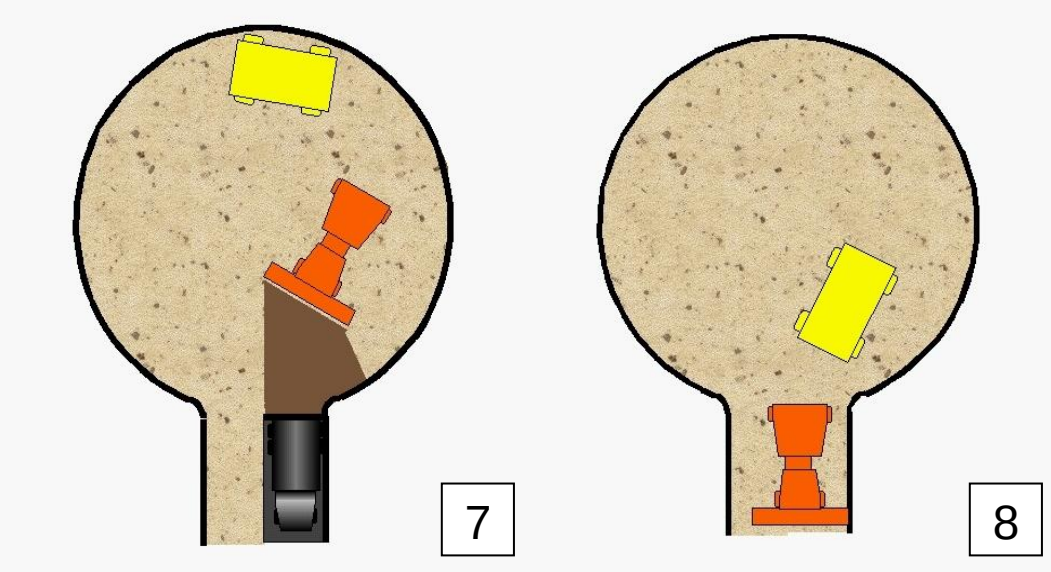


Begin rolling the first application of aggregate, as aggregate is applied to the remaining half of the cul-de-sac, and as the bituminous material is applied to the other edge.



Apply the bituminous material adjacent to the previous application.

Apply the aggregate along the other edge, as the first half continues to be rolled, and the final application of bituminous material is applied.



Finish applying the aggregate to the remaining bituminous material.

Complete rolling operations.

Appendix A

Standard Specifications For Road and Bridge Construction

(Adopted April 1, 2016)

Appendix B - References

Many of the references, illustrations, and photographs were obtain through field observations or from the following manuals.

Illinois Department of Transportation
Standard Specifications for Road and Bridge Construction
Adopted April 1, 2016

Minnesota Department of Transportation
Minnesota Seal Coat Handbook
Draft April of 1998

Washington State Department of Transportation
Asphalt Seal Coats
Revised March of 2003