Asphalt Surface Treatment
Best Practices Manual - 2018

NORTH CAROLINA
Department of Transportation

SUMMIT
DESIGN AND ENGINEERING SERVICES

Table of Contents

List of Figures

1. The Existing Roadway

The strength of Asphalt Surface Treatments (AST), Chip Seals in particular, is that they provide water proofing of the underlying structure. Chip Seals can be thought of as a wearing surface or a protective skin for the existing roadway. However, the Chip Seal cannot replace the need for a strong sub-base, so it is imperative that the existing surface be prepared correctly. This chapter will discuss the importance of correcting structurally deficient pavements, common causes of deficiencies, and symptoms of structurally deficient pavements; and will provide guidance for preparing the surface of the existing road for placement of the overlay.

Chip Seals will take the shape of the existing pavement. Therefore, if there are ruts, bumps or other surface issues in the existing pavement, Chip Seals will reflect up through the new overlay. The newly applied Chip Seal will follow the contours of the existing road, so an improvement in the road profile will not be achieved by this treatment. A single, double, or even triple seal is placed across the entire width of the road in a uniform pass and then rolled, not allowing any noticeable changes in the profile of the existing road.

To achieve maximum AST life expectancy, it is very important to repair structural defects that can cause movement in the existing pavement prior to applying an AST. Movement is often seen in pavements with excessive alligator cracking or rutting. These defects are normally present if water has been able to penetrate the stone, sand or soil sub-base, or if there is simply a lack of base material. When water is able to penetrate the sub-base, the material in the wheel path can become compacted or the base material can be washed to the top of the pavement. In either scenario, the strength of the base is compromised. Where there is a lack of base material, an increase in vehicular usage or the sudden presence of heavier trucks will cause the deflections in the pavement to become too great and the road profile will change shape. These types of defects will cause the AST to fail prematurely and, must be repaired before sealing. The following roadway assets will also need to be assessed prior to the AST application to prevent premature failure:

1. **Condition of shoulders**
2. **Positive drainage of ditch lines**
3. **Condition of x-line pipes**

Severe alligator cracking usually presents itself in one of two ways. The most common is in the form of potholes. As the existing pavement deflects, it will break into roughly three or four-inch square pieces which allows water into the base. This process will continue to grow on itself unless it is repaired. Alligator cracking can also appear in the wheel paths, where the weight of vehicles compacts the sub-base. These cracks run longitudinally along the length of the road and are associated with rutting. In either scenario, the underlying cause of alligator cracking is a lack of structural strength in the base. Rutting in the existing pavement caused by the weight of axle loading will typically cause a depression in the pavement profile. If properly sealed, water will sit on top of the pavement and create hydroplaning issues, because the water cannot run across the normal crown of the pavement. Where the pavement is cracked, water will penetrate the base and cause additional rutting or cracking. When rutting takes place in the inside or left-hand wheel path, slippery pavement will always follow because of water trapped in the rut. On the outside or right wheel path of typically narrow roads, rutting will cause the road to round. “Rounding” often leads to high shoulders where water is being trapped between the pavement and shoulder. The deformation of the base near the edge of the pavement will cause additional pavement deterioration, because of increased rutting and eventual cracking of the pavement edge. To repair this type of distress, the areas involved must be removed and additional base must be placed in the void areas. Care should be taken not to allow the new material to protrude higher than the profile of the undisturbed existing pavement surface.

The success of the Chip Seal also depends on the ability of the emulsion to bond the existing road to the aggregate placed on top. However, preparation of the existing road itself will always be required prior to the placement of new Chip Seal. To ensure the success of an AST, any loose material must be removed from the roadway surface. These materials include rock, dirt, dust, grass, and other debris. Any loose material will cause the seal to shell off and have the appearance of a pothole. Any raised pavement markers will have to be removed prior to Chip Seal Treatment. Any type of raised hump or bump in the pavement will create issues if it remains on the pavement prior to placement of the Chip Seal. If mud or dirt is caked on the road, it must be washed off. A mechanical broom is required to remove debris prior to Chip Seal Treatment and will also be used to remove excess aggregate once the Chip Seal has cured. The cleanliness of the road helps deliver an effective Chip Seal. Ensure existing pavement is clean, free of mud, dirt, rock, grass or any other debris by sweeping the existing road surface. Sweeping will be discussed further in Chapter 3.

Although this chapter has focused on the distresses which must be repaired prior to resurfacing, Chip Seals are also an excellent treatment for several other surface type distresses. Oxidation or aging, bleeding, raveling, and minor surface cracking are problems which a properly placed Chip Seal will correct. In these cases, the Chip Seal can extend the life of the pavement for five to seven years without the need for any further maintenance. The Chip Seal or other asphalt surface treatments will seal the cracks and put life back into the riding surface of the existing road.

Figure 1-1. The profile of a road.

Figure 1-2. Example of rutting.

Figure 1-3. Example of severe alligator cracking.

Figure 1-4. Example of a concrete patch.

Figure 1-5. Example of poor shoulder work.

2. Types of Pavement Preservation

2014 North Carolina General Statutes
Chapter 136 - Transportation.
Article 2A - State Transportation Generally.
§ 136-44.17 - 17. Pavement preservation program.
Universal Citation: NC Gen Stat § 136-44.17 (2014)

136-44.17. Pavement preservation program.

(a) Program Established. - The Department of Transportation shall establish the pavement preservation program.

(b) Eligible Activities or Treatments. - Applications eligible for funding under the pavement preservation program include the following preservation activities or treatments for asphalt pavement structures:
(1) Chip Seals, Slurry Seals, Fog Seals, Sand Seals, Scrub Seals and Cape Seals.
(2) Microsurfacing.
(3) Profile milling not covered by resurfacing.
(4) Asphalt rejuvenators.
(5) Open graded asphalt friction course.
(6) Overlays less than 1,000 feet in length.
(7) Diamond grinding.
(8) Joint sealing.
(9) Dowel bar retrofit.
(10) Partial-depth or full-depth repairs and reclamations.
(11) Ultra-thin whitetopping.
(12) Thin lift and sand asphalt overlays.

(c) Ineligible Activities or Treatments. - The pavement preservation program shall not include the following preservation activities or treatments:
(1) Contract resurfacing activities or major pavement rehabilitation treatments and pretreatments that are used in combination with a resurfacing treatment, such as profile milling or chip seals.
(2) Routine maintenance activities used to maintain and preserve the condition of roads. Treatments include, but are not limited to, asphalt crack sealing, pothole patching, rut filling, cleaning of roadside ditches and structures, shoulder maintenance, and retracing of pavement markings.
(3) Maintenance and preservation activities performed on bridges or culverts.
(4) Activities related to positive guidance or signal maintenance program functions. (2014-100, s. 34.11(f).)

Definition of eligible activities or treatments:

Chip Seals: Ideal pavement Preservation for existing lower volume roadways without structural related problems i.e. rutting, typical distortions. Chip Seal (AST) consists of application of emulsified asphalt followed by application of evenly graded aggregate static rolled to provide proper embedment of aggregate. Chip Seal can be used ahead of hot mix asphalt resurfacing to slow the process of reflective cracking through newly placed asphalt.

Slurry Seals: Ideal application on newly installed chip seals to provide enhanced aggregate retention. Product is a mixture of emulsified asphalt, mineral fillers and lime. Applied with asphalt distributer and drag box to provide fulfillment of smallest voids.

Fog Seals: Ideal application on newly installed chip seals to provide enhanced aggregate retention. This application gives the appearance of hot mix asphalt and is received and accepted well by the traveling public.

Sand Seals: Application of emulsified asphalt followed by an application of fine aggregate and then static rolled. Sometimes used to provide protective layer to base and intermediate layers of asphalt which cannot be covered with surface type mix during paving season due to weather limitations.

Scrub Seal: Not typically used on NCDOT projects at this time.

Cape Seals: Application of emulsified asphalt with fine aggregate content usually applied to recently placed Chip Seal. Provides improved aggregate retention as well as filling smallest of voids in Chip Seal. Well received as a finished product by motorists.

Microsurfacing: Application of emulsified asphalt, fine aggregate and various admixture to correct very minor rutting or cracking of existing asphalt surfaces. Provides skid resistance and extends pavement life cycle.

Profile Milling not covered by resurfacing: Not typically used on NCDOT projects at this time.

Asphalt Rejuvenators: Not typically used on NCDOT projects at this time.

Open Graded Friction Course: A pavement surface course which consists of a high-void, asphalt plant mix which permits rapid drainage of rainwater through the course and out the shoulder. The mixture is characterized by a large percentage of one-sized coarse aggregate. This course prevents tire hydroplaning and provides a skid resistant pavement surface.

Overlays less than 1,000 feet in length

Diamond Grinding: Not typically used on NCDOT projects at this time.

Joint Sealing: Pavement Preservation tool using joint sealer of both hot and cold applications to seal cracks in both Portland Cement and Asphalt pavements. The success of this type of operation is the correct preparation of existing cracks to ensure all incompressible dirt/debris is removed using compressed air along with torch to eliminate any moisture which may prevent sealant bonding. Other tools used in this type of operation are backer rod and joint routers to provide vertical wall of existing cracks. It is critical to avoid over banding of crack with sealant to prevent later problems with future asphalt over lays.

Dowel Bar Retrofit: Not typically used on NCDOT projects at this time.

Partial-Depth or Full-Depth repairs and reclamations: Consists of removal and replacement of asphalt down to sub-grade and can include aggregate base course if full depth. This type of preservation is used when there are areas of pavement which are considered structurally unstable with large ruts or slippage in pavement is present.

Ultra-thin Whitetopping: Not typically used on NCDOT projects at this time.

Thin Lift and Sand Asphalt Overlays: A mixture of sand, natural and/or manufactured, and asphalt cement. It may be prepared with or without special control of aggregate grading and may not contain mineral filler. Either mixed-in-place or plant mix construction may be employed. Sand asphalt is used in construction of both base and surface courses.

3. Tools of the Trade

Emulsion Distributor

The distributor is used to apply a uniform layer of liquid asphalt or emulsion to the roadway at a specific rate and within a specific temperature range. It has a truck-mounted insulated tank and spray bar capable of circulating emulsion at a constant temperature. The heating system must be able to maintain the emulsion temperature within the operation range. Distributors normally range from 800 to 2,500 gallons. The distributor is equipped with a valve system which controls the emulsion internal to the tank while allowing circulation through the spray bar which controls the flow of the emulsion. It will have a foot meter to record linear distance of emulsion laydown and a pressure gauge or tachometer which registers pump output. These values will be important to calculate application rates during Chip Seal Treatment. The spray bar is normally 8 to 14 feet wide and can be adjusted to the appropriate width of the roadway. It has adjustable nozzles, usually set between 15 and 30 degrees to allow uniform application and overlap of the emulsion during spraying. The spray bar also has a height adjustment to allow single, double or triple coverage of the emulsion spray as it is applied to the roadway.

For most North Carolina locations, the double coverage lends itself to the most accurate laydown. The single coverage can allow streaking at times, and the height off the road needed for the triple coverage can sometimes be affected by wind. Both circumstances can cause a non-uniform application of the emulsion. The spray bar has to be able to apply the emulsion under pressure and in a uniform layer across the width of the roadway and sustain the application rate as the distributor travels down the length of the roadway. The distributor will also need a hand wand for applications where it is impractical to apply the total width of the spray bar without causing overlap in emulsion application which leads to areas of bleeding.

To summarize, the key elements of an emulsion distributor must have the following:

- **Truck mounting**
- **Ability to heat and circulate emulsion**
- **Ability to control automated application rates**
- **Hand operated wand for irregular areas**

Figure 3-1. Asphalt distributor operating at the proper spray bar height to apply double coverage, courtesy of E.D. Etnyre & Company.

Figure 3-2. Asphalt distributor in use.

Stone Spreader

The stone spreader is used to apply a uniform layer of aggregate to the roadway at a specific rate. The stone spreader is self-propelled. It is equipped with a hopper at the rear which accepts bulk aggregate from a dump truck, a delivery, or belt system internal to the machine which carries the aggregate to the front of the machine, and a series of gates on the front hopper which applies a uniform layer of aggregate across the width of the roadway. The front hopper is normally 10 to 12 feet wide. The width of the laydown can be adjusted by turning on or off gates. The spreader should be able to connect to the dump truck and pull it along the roadway. This eliminates excessive spillage between the spreader and the truck. Frequent inspection of stone spreader hopper belts will prevent aggregate spillage which will cause premature failure in chip seals.

To summarize, the key elements of a stone spreader must have the following:

- **Self-propelled**
- **Front hopper normally 10 plus feet wide (variable)**
- **Ability to tow aggregate haul truck**
- **Manual or automated operation**

Figure 3-3. Stone spreader attached to dump truck.

Dump Truck

The dump truck is used to deliver aggregate to the stone spreader. Two adjustments are sometimes required for the dump truck. One adjustment is a hitch which will allow connection to the spreader for towing down the road. The other adjustment is the addition of fins around the tailgate to stop aggregate from spilling out while the spreader is attached to the dump truck with the dump bed raised. Aggregate will flow from the dump truck into the rear hopper of the stone spreader and will easily overflow without the fins attached. The spreader will then pull the Dump Truck along the operation.

To summarize, the key elements of a dump truck are as follows:

- **Proper tow hitch**
- **Appropriate shields to avoid aggregate spillage**

Figure 3-4. Dump truck with shield and hitch.

Pneumatic Roller

A pneumatic tire roller should be the first roller to embed the aggregate into the emulsion. The independent and flexible movement of the tires allows the roller to compress the aggregate into the emulsion without bridging over the minor depressions inherent to the roadway surface. The pneumatic roller will provide excellent aggregate realignment after placement by the spreader. A self-propelled pneumatic tire roller will allow the aggregate to be compressed uniformly because it follows the contours of the existing road. The rolling process will be described more fully in Chapter 9, but for maximum effectiveness, the rollers must follow the stone spreader closely, so the seating of the aggregate will take place prior to the emulsion breaking.

To summarize, the key elements of a pneumatic roller operation are as follows:

- **First roller used after stone spreader, seating aggregate**
- **Independent movement of tires**
- **Accomplishes rolling within 3-5 minutes of emulsion and aggregate placement**

Figure 3-5. Pneumatic tire roller (Background) being followed by static steel wheel roller (Foreground).

Static Steel Wheel Roller

The final passes of the rolling process will be performed by a static steel wheel roller. The steel wheel roller will further assist in arranging the aggregate into the emulsion to provide a better bond between the aggregate and emulsion. The steel wheel roller cannot be too heavy because it will crush the aggregate. The steel wheel roller must be operated without the vibrating function of the roller switched on. The compaction effort is not needed to obtain a specific density, but rather to bind the aggregate to the emulsion. The ability of the finished treatment to bind the individual aggregate pieces together and to the existing roadway by the emulsion is what gives the Chip Seal its strength and extended service life.

To summarize, the key elements of a static steel wheel roller operation are as follows:

- **Further assists in seating aggregate**
- **Monitors roller weight to avoid crushing aggregate**
- **No vibration function used**
- **Provides finished arrangement of aggregate**
- **Accomplishes rolling within 3-5 minutes of emulsion and aggregate placement.**

Combination Roller

The NCDOT has introduced the combination roller over the last few years, and the machine's performance has been positive. It is a combination of a pneumatic tire roller in the front and a steel wheel roller in the back. The combination roller can provide the qualities of both rollers on one machine. It does not reduce the number of passes required, but in the event of a breakdown of one of the other rollers, it could keep production moving. Rollers and rolling patterns will be discussed in Chapter 9.

To summarize: The key elements of a combination roller are as follows:

- **New type of roller**
- **Has combination of pneumatic tires and steel wheel**

Figure 3-6. Combination roller in use.

Mechanical Broom

The first and last piece of equipment which will be used on a project is the mechanical broom. It will be used to begin the AST process by removing any debris from the roadway. After the AST has cured, the mechanical broom is used to remove any loose aggregate. This should take place within a three to seven-day time frame. Care has to be exercised when sweeping after the AST has cured. Excessive force or down pressure can damage the integrity to the newly placed AST.

To summarize: The key elements of a mechanical broom and operation are as follows:

- **Used to sweep road prior to AST application to remove debris**
- **Used to sweep loose aggregate from roadway after curing period**
- **Avoid excessive down pressure during back sweeping to avoid damage to newly placed AST**

Figure 3-7. Mechanical broom in use.

Vacuum Truck

The use of vacuum trucks to retrieve loose aggregate after AST is also permitted. The vacuum truck eliminates the sweeping action of the broom and reduces the chance of dislodging the aggregate from the AST. This method may be most effective in subdivisions to minimize aggregate being swept into manicured yards.

To summarize: The key elements of a vacuum truck are as follows:

- **Alternative method to remove loose aggregate**
- **Excellent devise to avoid sweeping loose aggregate into yards such as in subdivisions**

Figure 3-8. Vacuum truck in use.

Calibrating Equipment

The ability to adjust both emulsion and aggregate application rates in the field is required to comply with the contract specifications. Calibrating the equipment at the beginning of the season by adjusting nozzle angles and the height of the spray bar will help ensure accurate application rates. The speed and pressure settings for the asphalt distributor must be adjusted for the type of emulsion being applied. In addition to using the appropriate settings on the asphalt distributor and stone spreader, records of daily application quantities will be required to verify actual production rates. Subsection 660-9 of the Standard Specifications states the following: For any type of AST work, demonstrate that all equipment has been calibrated in the presence of the engineer with a minimum 100-foot test section. If the test section is not feasible, submit a calibration plan to the engineer with detailed information on equipment and a designated area for calibration. The following technique will guide the operators in applying the proper rates.

The two factors which affect uniform applications are the nozzle angle and the height of the spray bar. The nozzles should be between 15 and 30 degrees. The spray bar on the distributor should be adjusted prior to running a test strip for the emulsion. It is recommended the emulsion be applied at a spray bar height which provides double coverage. The distributor is now ready for the 100-foot test section.

The rate of emulsion application is measured in gallons per square yard (gal/yd2). A minimum 100-foot test strip is used to determine the quantity of emulsion needed. The quantity of emulsion in the distributor will be recorded at the beginning and end of the test section. The 100 linear feet of the test trip is multiplied by the width of spray to determine the area in square feet. Dividing the total square feet by nine converts the measurement to square yards. Divide the gallons used by the area to obtain gallons per square yard. Observe the pull to make sure the emulsion is evenly covering the section. Also, check that the spray bar height and the individual nozzle spray widths are double covering the existing road. Depending on the type of distributor used, the pressure or RPMs required to provide the desired rate should be recorded. The temperature of the emulsion will affect the spray pattern so be sure to have the emulsion within the operating range of 160 to 170 degrees Fahrenheit.

SECTION 660
ASPHALT SURFACE TREATMENT

660-1 DESCRIPTION

Perform the work covered by this section including, but not limited to, furnishing, hauling, spreading and rolling the emulsion and aggregate consisting of one or more applications of liquid asphalt material and one or more applications of aggregate cover coat material on a prepared surface; and maintaining and repairing the asphalt surface treatment (AST).

660-2 MATERIALS

Refer to Division 10.

Item	Section
Aggregates for Asphalt Surface Treatment	1012-2
Emulsified Asphalt, Grade CRS-2L	1020-3
Emulsified Asphalt, Grade CRS-2P	1020-3
Fine Aggregate	1014-1
Mineral Filler	1012-1(D)
Water	1024-4

Before any asphalt surface treatment is placed, obtain from the asphalt supplier and furnish to the Engineer a Certification of Compatibility of the emulsion with the aggregate proposed for use.

660-3 WEATHER AND SEASONAL LIMITATIONS

Do not place any asphalt surface treatment between October 15 and April 1, except for asphalt surface treatment that is to be overlaid immediately with asphalt plant mix.

Apply AST only when the surface to be treated is dry and when the air or surface temperatures, measured at the location of the AST operation away from artificial heat, is 50°F and rising. Do not place AST when air temperature is 98°F and rising.

When placing AST that is to be immediately overlaid with asphalt plant mix, the seasonal and temperature limitations of Article 610-4 shall apply.

Do not apply asphalt material when the weather is foggy or rainy.

660-4 SURFACE PREPARATION

Clean the surface to be treated of dust, dirt, clay, grass, and any other deleterious matter before application of the AST.

660-5 ACCEPTANCE OF ASPHALT MATERIALS

The acceptance of asphalt materials will be in accordance with Article 1020-1.

660-6 APPLICATION EQUIPMENT

Use asphalt application equipment that meets Article 600-5.

Apply aggregate by the use of a self-propelled, pneumatic-tire aggregate spreader capable of maintaining a specified rate with a uniform application for the width of asphalt material being covered. Tailgate spreaders will not be permitted. Areas that are inaccessible to the aggregate spreader shall be covered by hand spreading or other acceptable methods.

660-7 AGGREGATE TYPE AND APPLICATION RATES

Contractor shall provide aggregate types and rates as specified in the contract.

660-8 CONSTRUCTION METHODS

For any type of AST work, demonstrate that all equipment has been calibrated in the presence of the Engineer with a minimum 100 foot test section. If approved by the Engineer, test section may be incorporated into the production section. If the test section is not feasible, submit a calibration plan to the Engineer with detailed information on equipment and a designated area for calibration.

(A) Asphalt Seal Coat

Use the type of seal coat as required by the contract. Seal coat aggregates shall be drained of free moisture and have an amount passing the #200 sieve no greater than 1.5% in accordance with Table 1005-1 before use. Place the seal coat in full-lane widths. Adjust the aggregate rates to provide a sufficient quantity of cover material to be spread over the surface of the seal coat preventing traffic damage, where it is necessary to permit traffic on sections of a completed seal coat.

Perform rolling of each layer immediately after the aggregate has been uniformly spread. Rolling will consist of at least three complete coverages with one pneumatic-tire roller followed by at least one complete coverage with a 5 to 8 ton steel-wheel roller. All roller coverages shall be completed within 5 minutes of the asphalt emulsion being placed. Do not allow crushing of the aggregate or picking up of the material by the rollers.

The use of a combination steel-wheel and pneumatic-tire roller 1 will be permitted instead of the 5 to 8 ton steel-wheel roller.

After the aggregate is thoroughly seated, broom all excess aggregate off of the surface of the seal coat after 3 calendar days but no more than 7 calendar days. If necessary, use a vacuum truck as directed by the Engineer. Traffic may be permitted on the seal coat immediately after the rolling is complete.

Clean driveways, ditches, turn lanes, and areas adjacent to the AST construction of excess aggregate, excess emulsion run off, over spray or debris from construction.

Blotting sand may be required as directed by the Engineer and shall be applied in accordance with Section 818.

The construction of the various types of seal coats will be in accordance with the following additional requirements:

(1) Single Seal

Apply emulsion to the existing surface followed immediately by an application of aggregate as specified in the contract. Uniformly spread the full required amount of aggregate in one application and correct all non-uniform areas before rolling. Immediately after the aggregate has been uniformly spread, perform rolling as previously described.

(2) Double Seal

Apply emulsion to the existing surface followed immediately by an application of aggregate as specified in the contract ensuring each is uniformly placed over the existing surface and rolled as previously described.

Immediately after the first application of seal aggregate has been made uniform and rolled, apply the second application of the required amount of emulsion and seal coat aggregate and roll as previously described.

(3) Triple Seal
Follow the procedure outlined in Subarticle 660-8(A)(2) and apply emulsion and aggregate as a third layer and roll as previously described.

(4) Sand Seal
Place the fully required amount of asphalt material in one application and immediately cover with the seal coat aggregate. Uniformly spread the fully required amount of aggregate in one application and correct all non-uniform areas before rolling.

Immediately after the aggregate has been uniformly spread, perform rolling.
Broom excess aggregate material from the surface of the seal coat.
When the sand seal is to be constructed for temporary sealing purposes only and will not be used by traffic, use other grades of asphalt material meeting the requirements of Articles 1020-5 and 1020-6.

(B) Asphalt Mat and Seal
Construct the mat coat in accordance with Subarticle 660-8(A) using the size aggregate required by the contract.
Construct the seal coat in accordance with Subarticle 660-8(C) using the type seal required by the contract.

(C) Asphalt 1 Mat Coat for Soil Subgrade
The surface on which the mat coat is to be applied shall be approved by the Engineer before the mat coat emulsion is applied.
Place a string line guide for application equipment. Place the mat coat in full-lane widths.
Existing surface shall be damp prior to placement of the mat coat.
Immediately follow the application of emulsion with the spreading of the aggregate.
No more than 5 minutes can elapse from the time the emulsion is applied and the rolling is completed when using CRS-2L or CRS-2P.
Mat coat aggregate shall be drained of free moisture and have an amount passing the #200 sieve no greater than 1.5% in accordance with Table 1005-1 before use. Spread the aggregate uniformly at the required rate and correct all non-uniform areas before rolling.
Roll immediately after the aggregate is uniformly spread. Rolling consists of at least three complete coverages with two 5 to 10 ton steel-wheel rollers. Continue rolling until the aggregate is thoroughly keyed into the emulsion. Do not allow crushing of the aggregate or picking up of the material by the rollers. A combination steel-wheel and pneumatic-tire roller will not be permitted. Use two individual steel-wheel rollers. The three coverages shall be completed within 5 minutes of the spraying of the emulsion.
At the discretion of the Engineer, at the beginning of each emulsion application, spread a paper over the end of the previously completed mat coat and begin the asphalt application on the paper. After application, remove and dispose of the paper.
After the aggregate is thoroughly seated, traffic may be permitted on the mat coat after the rolling is complete. No brooming shall be performed on the mat coat.
Correct defects or damage to the mat coat before the application of seal coat or plant mix overlay. The seal coat or plant mix may be applied the same day the mat coat is placed provided the mat coat has been satisfactorily applied and rolled.

(D) Asphalt Mat Coat for Pavement Surfaces
For mat coats with an asphalt overlay, construct the mat coat in accordance with Subarticle 660-8(C). The same grade of emulsion used for the mat coat may be used for the tack coat of the asphalt overlay.
For mat coats constructed on existing pavement surfaces, construct the mat coat in

accordance with Subarticle 660-8(C) using the size aggregate required by the contract and the application rates specified in the contract.

660-9 TEMPORARY TRAFFIC CONTROL (TTC)

All AST operations shall be conducted in daylight hours.

Provide temporary traffic control for the asphalt surface treatment operations in accordance with the contract and in accordance with the provision RWZ-1 TEMPORARY TRAFFIC CONTROL (TTC) found elsewhere in the proposal except the following sections do not apply:

TRAFFIC OPERATIONS, Drop-Off Requirements and Time Limitations

TRAFFIC OPERATIONS, Project Requirements

Install advance/general warning work zone signs according to the Detail Drawing titled *Signing for Asphalt Surface Treatment* provided in the plans.

660-10 WARRANTY

The AST shall be warranted by the project payment and performance bonds for a period of 12 months.

6-45

Section 660

(A) Warranty Period

The Department will conduct an inspection of the work and provide written acceptance in accordance with Article 105-17. Written acceptance of the work will constitute the start date for the 12 month AST warranty period.

(B) Situations Affecting the Warranty

During the warranty period, the Contractor will not be held responsible for distresses that are caused by factors not related to materials and workmanship. These include, but are not limited to, chemical and fuel spills, vehicle fires, base failures, and snow plows. Other factors considered to be beyond the control of the Contractor, which may contribute to pavement distress, will be considered by the Engineer on a case by case basis upon receipt of a written request from the Contractor. Maintaining traffic on the pavement surface prior to the Engineer's acceptance will not be a condition for voiding the warranty.

(C) Emergency Repairs

If, in the opinion of the Department, a pavement condition covered by the warranty requires immediate attention for the safety of the traveling public, the Contractor will be notified immediately. If the Contractor cannot perform the work in a timely manner, the Department may directly perform or have the corrective work performed by another entity at the Contractor's expense. Any emergency work performed will not alter the requirements, responsibilities, or obligations of the warranty.

(D) Warranty Performance Criteria

TABLE 660-1
PERFORMANCE CRITERIA

Surface Defects	Severity	Extent (Per Lot)
Surface Patterns	Alternate lean and heavy lines streaking over the entire pavement	Greater than 20% of a lot affected; distress spotted evenly over the lot or

	surface.	over localized area within the lot.
Bleeding/ Flushing	Distinctive appearance (with excess asphalt binder already free).	Greater than 20% of the wheel tracks within a lot affected.
Loss of Cover Aggregate	Large patches of cover aggregate lost from the pavement surface.	Greater than 20% of a lot affected; distress spotted evenly over the lot or over localized areas within the lot.

Lot – A 1,000 foot section of pavement or portion thereof, a lane width wide, on which AST is constructed on a single map.
The beginning point of the first lot will be the beginning point of each day's operation or the beginning of a map, whichever is applicable.
The Department will review the AST and advise the Contractor of any required corrective work in writing prior to expiration of the warranty period.
The Department will approve all materials and methods used in warranty work.
The Department will determine if warranty work performed by the Contractor meets the contract and provide written acceptance of the warranty work when complete.

The Chief Engineer will review any disputes for corrective 1 work covered under the warranty.

660-11 MAINTENANCE

Maintain the asphalt surface treatment in an acceptable condition until final acceptance of the project.

660-12 MEASUREMENT AND PAYMENT

Asphalt Surface Treatment: Single Seal, Double Seal, Triple Seal, Mat and Single Seal, Mat and Double Seal, Sand Seal, and Mat Coat, No.___Stone. All AST will be measured and paid at the contract unit price per square yard. Payment at the above prices will be made for replacing any satisfactorily completed AST when such replacement has been made necessary by defects in subgrade or base constructed by others.

Emulsion for Asphalt Surface Treatment will be measured by the actual surface area of application and the specified application rate (gallon/sy) and paid at the contract unit price per gallon, which price will be full compensation for all materials including modifiers and additives, tack coat, labor, tools, equipment, and all other incidentals necessary to complete the work.

Vacuum truck will be measured and paid on a weekly basis for each week or any portion thereof that the Engineer directs the use of a vacuum truck.

Price adjustments herein shall apply concurrently; however, price adjustment will not apply in the event the material is rejected.

Furnishing and applying prime will be paid as provided in Article 600-9 for *Prime Coat*.

If included in the contract, furnishing and applying blotting sand will be paid as provided in Article 818-4 for *Blotting Sand*.

Adjustment for *Emulsion for AST* will be paid per the following formula:

$$A = B + ((D - C) / 235)\ 0.65$$

Where:

A = Adjusted Contract Unit Price of *Emulsion for AST* per gallon
B = Contract Unit Price of *Emulsion for AST* per gallon
C = Base Price Index of PG 64-22 per ton
D = Monthly Average Terminal F.O.B. Selling Price for PG 64-22 per ton

See Price Adjustment – Asphalt Binder Special Provision found elsewhere in this proposal for the base price index of PG 64-22 per ton.

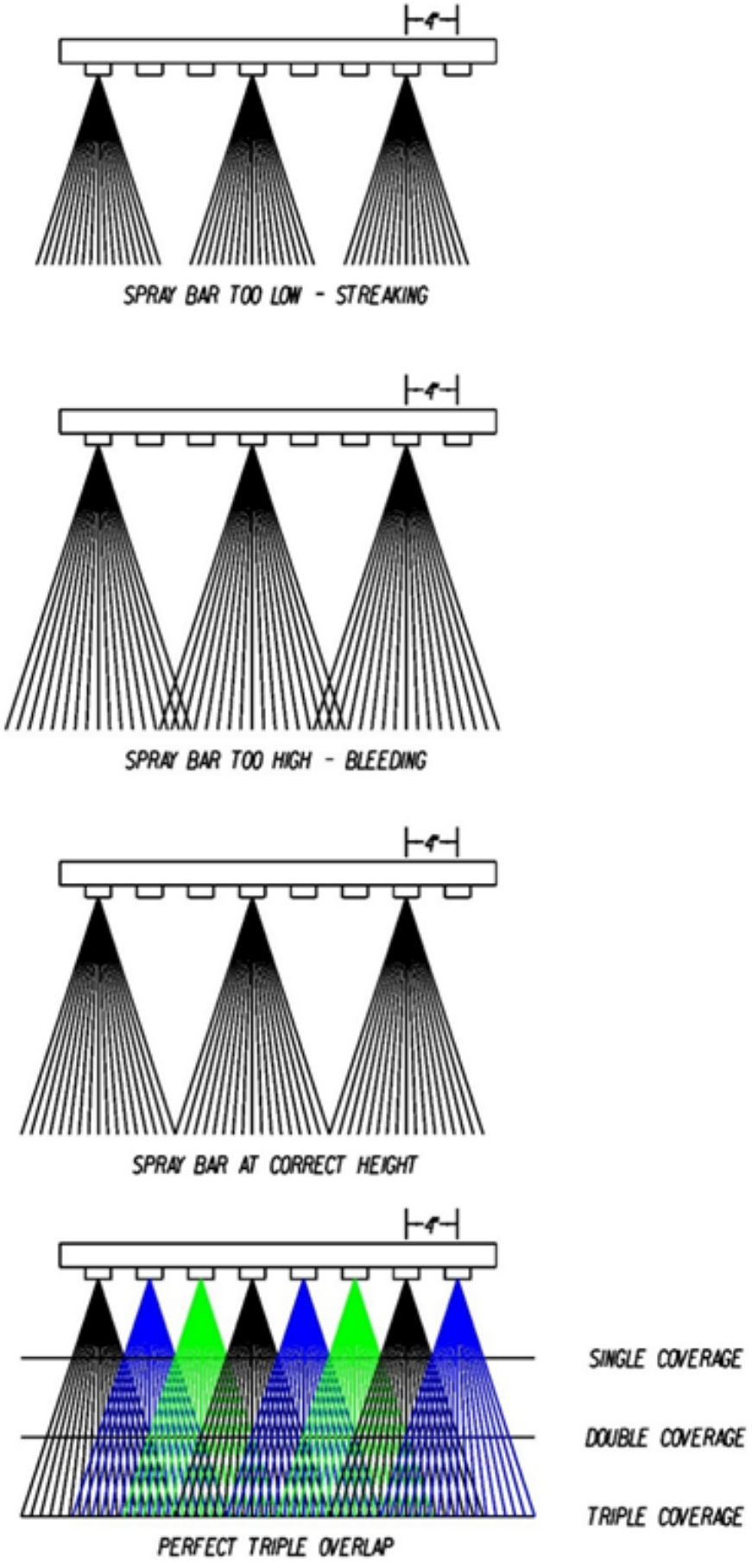
Payment will be made under:

Pay Item	Pay Unit
Asphalt Surface Treatment, Single Seal	Square Yard
Asphalt Surface Treatment, Double Seal	Square Yard
Asphalt Surface Treatment, Triple Seal	Square Yard
Asphalt Surface Treatment, Mat and Single Seal	Square Yard
Asphalt Surface Treatment, Mat and Double Seal	Square Yard
Asphalt Surface Treatment, Sand Seal	Square Yard
Asphalt Surface Treatment, Mat Coat, No. __Stone	Square Yard
Emulsion for Asphalt Surface Treatment	Gallon
Vacuum Truck	Per Week

Key Notes

- **Calibrate at the beginning of the season and as needed or required by engineer.**
- **Ensure correct angle of bar nozzles.**
- **Ensure spray bar height is correct to provide proper uniform emulsion application.**
- **Perform daily spot calibration of distributor to ensure correct emulsion application is recommended.**
- **Calibration strip should be at least 100 feet long and the width of area being treated.**
- $\frac{\text{Length x Width}}{9} = \text{S.Y.}$
- $\frac{\text{Actual Gallons}}{\text{S.Y.}} = \text{Rate (G/S.Y.)}$
- **Ensure emulsion is between 160 and 170 degrees Fahrenheit at time of application.**

Figure 3-9. Examples of spray bar heights.



The rate of aggregate application is measured in pounds per square yard (lbs/yd2). To determine the amount of aggregate used, place a tightly-woven sample cloth at several locations across the width of the aggregate spreader hopper. The material used to collect the aggregate should be cut to exactly one square yard and weighed prior to application. Spread the aggregate and then weigh the material plus aggregate and subtract the difference. This will be the weight of the aggregate spread over one square yard. This is a simplistic way of calibrating the equipment and will help prevent under or over-applying aggregate. When the weights are close to the specifications directed for use and a uniform aggregate pattern is obtained across the mat, the stone spreader settings can be recorded for use in the field. Adjustments for the various application rates can then be based on the findings from the approved location.

The emulsion will be quantified and paid by the gallon while the aggregate will be quantified and paid by the square yard. The total quantity of materials will be calculated per map or per day, depending on the amount of production completed. This information will be collected on the inspector's daily log, and it will be used to calculate the final rates for the emulsion and aggregate used per map. These rates should be within the guidelines required by the contract. See Chapter 13 for further discussion on this topic. For further clarification, refer to the NCDOT 2018 Standard Specifications for Roads and Structures Section 660-12 "Measurement and Payment."

Key Notes

- **Place down a sample cloth to capture a one stone coverage by the spreader. Ensure complete coverage. Weigh this material and record as the calibration target weight.**

- **Place multiple sample cloths secured to avoid movement across width of stone spreader. Drive stone spreader over area to carefully remove sample cloths and weigh each square yard of aggregate. Continue until uniform target weight is achieved. Adjust equipment as needed to achieve desired application rates.**

Figure 3-10. Calibration of the stone spreader.

4. Emulsion and Aggregate

This chapter deals with the asphalt emulsions and aggregates use in Chip Seal production only. **The recommended asphalt emulsion grades used in North Carolina are CRS-2L or CRS-2P for AST production.** These grades have been field tested and used by the NCDOT for the last several years. They have proven to be very durable, long-lasting, and to give good aggregate retention. The loss of aggregate (loose rock) once placement is complete is one of the issues that cause a reduction in the service life of Chip Seal treatments. **The use of the latex-modified or polymer-modified grade asphalt emulsions has greatly improved the performance of Chip Seals and reduced the number of complaints from the traveling public.**

By design, emulsions are mixtures of liquid asphalt and water, with additives for stability. The handler must keep the mixture circulated and within a certain temperature range. **If the temperature drops below 100 degrees, the asphalt starts separating out. If the temperature exceeds 200 degrees, the water starts boiling out.** If care is not exercised in storing the emulsions, problems will be encountered during and after the Chip Seal Treatment process is completed. The proper storage and handling of these emulsions are paramount to the success of a Chip Seal.

The two emulsions recommended for use by the NCDOT have the CRS designation, which stands for Cationic Rapid Set. This implies that the emulsion will have a slightly positive charge. This helps the emulsion remain stable and will enhance the retention of aggregate, provided the aggregate has a slightly negative charge. Most aggregates produced in North Carolina have a slightly negative charge. **A Certificate of Compatibility must be obtained from the asphalt supplier showing that the proposed aggregate and emulsion are approved for use. This certificate must be provided prior to beginning work.** In Chapter 5, Section 660-2 of the Standard Specification details can be found in assisting with the Certificate of Compatibility.

Aggregate, the other major player, also has characteristic storage and handling requirements to ensure the Chip Seal is going to be successful. The choice of aggregate is as vital as the choice of emulsion. The compatibility, shape, hardness, and cleanliness of the aggregate will determine the overall function and effectiveness of the Chip Seal. The ability of the aggregate to bond properly to the emulsion provides the strength and durability of a Chip Seal. Assuming the Certificate of Compatibility is obtained, the following characteristics of the aggregate must also be taken into consideration.

Uniform size and shape are two attributes that are very important in the choice of aggregate. The aggregate should be gap graded and relatively the same size. **When the aggregate is realigned under the roller, the theoretical result is a layer of uniform size stone.** If small pieces are present, the aggregate can be completely submerged in the emulsion whereas larger pieces can bridge the emulsion and only have partial absorption. If the aggregate is not of uniform size and shape, the success of the Chip Seal can be compromised.

Other important qualities of the aggregate are cleanliness and hardness. **The aggregate must be washed of all dust and sand.** It is important the surface of the individual particles is free from dust and sand to provide a clean surface for the bonding of the asphalt to the surface of the stone. **Care should also be taken to ensure the aggregate is not too soft.** If the aggregate crushes under the roller, the fractured pieces will shell off and create the same type of pavement failure as the dirty aggregate: a bleeding road with no aggregate for strength.

Figure 4-1. Alternate aggregate sample.

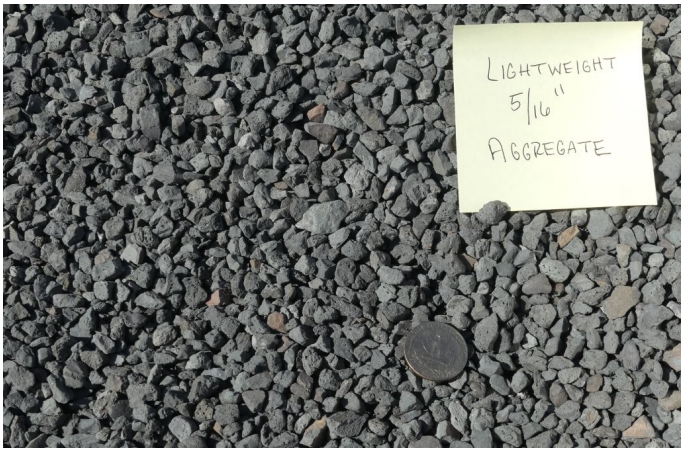


Figure 4-2. High quality aggregate sample.

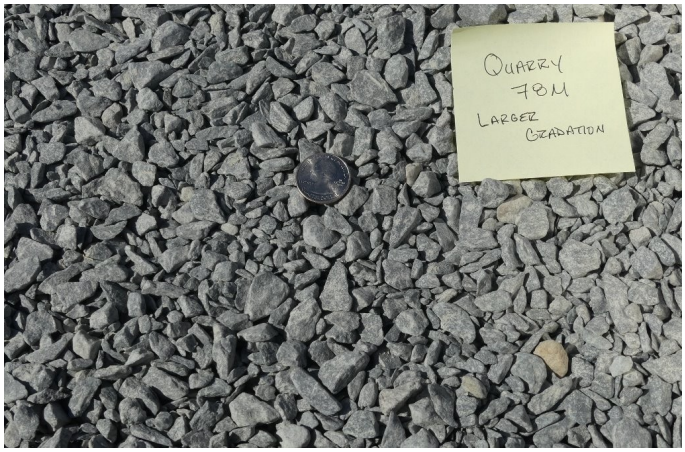


Figure 4-3. Poor quality aggregate sample.

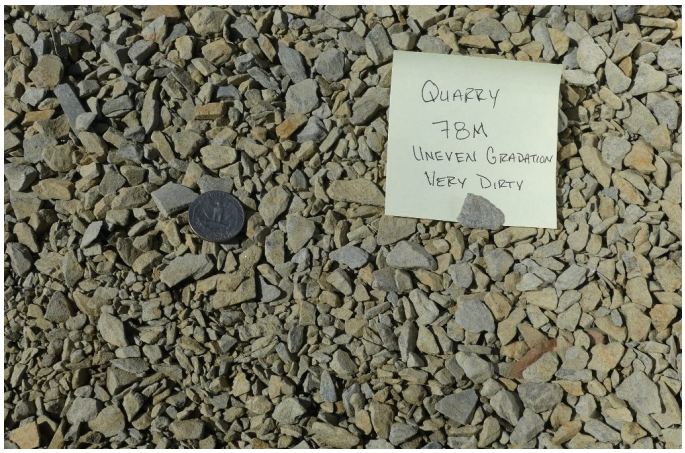
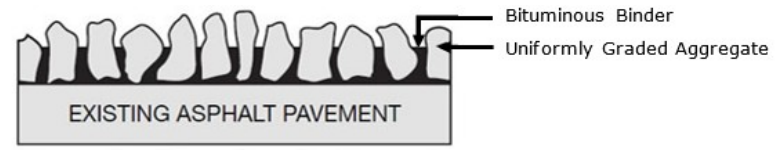
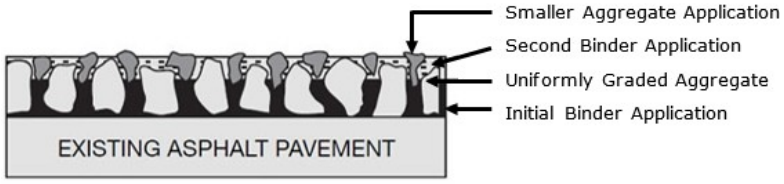


Figure 4-4. Chip Seal Diagram.



Cross-section of a one-size seal coat aggregate



Double Seal (2 layers of binder and aggregate)

5. The Specifications

The NCDOT has had standard specifications for AST for years. These have been adjusted over time because materials have changed over the years. The specifications were adequate for certain road conditions but did not allow for the variability of pavement conditions across the state. The rigid rates often created failures in the final pavement not because of workmanship, but because the specifications needed to be adjusted due to field conditions. As a result, the new standards have been developed to allow the pavement design engineer to modify the type and rate of seal to be placed on the road. The new specifications also allow the contract to be paid in quantities of material (gallons of emulsion and square yards of AST). The engineer determines the pavement structure to provide the amounts of asphalt and aggregate in each lift that is more inclined with the existing pavement state of repair.

- **Adjustment in emulsion rates allowed is 0.03 gal/S.Y.**
- **Oxidation is a common problem in existing roadway surfaces.**
- **Bleeding may require reduction in emulsion gal/3y on first application range 0.03 gal/S.V. still applies.**

6. "Weather" to Pave or Not

After securing the materials, equipment and the right pavement design, the final question is "weather" or not it is time to pave. Chip Seals are very temperamental, and the weather conditions will play a big role in the ultimate success of the seal. Given the extreme volatility of asphalt emulsions, atmospheric conditions have the potential to cause great problems. For example, excessive heat or moisture can cause problems in the binding of the asphalt to the aggregate. This chapter will deal with the weather and how it can affect the outcome of the Chip Seal.

Moisture

When an emulsion and aggregate are placed, rolled and allowed to cure properly, the success of the seal is almost guaranteed. However, the correct amount of moisture is critical to this process. The key to aggregate retention is the ability of the asphalt in the emulsion to lock onto the aggregate before the emulsion breaks or sets. Basically, the water in the emulsion needs to evaporate out leaving the asphalt to bind the individual pieces of aggregate to each other and to the road. **High moisture levels will erode the binding properties, effectively destroying the Chip Seal.** The amount of moisture present must be taken into consideration as the pavement is being placed and as the pavement is breaking after the rolling is complete.

Excessive moisture in the form of rain or high humidity is the primary culprit for most unsuccessful Chip Seal operations. The added presence of water during production can cause the pavement to bleed. **Afternoon showers have the potential to cause the asphalt to release its bond from the aggregate and float to the top of the aggregate.** The asphalt can then run off the road onto the shoulder and onto driveways along the side of the road, turning driveways black with asphalt. This is the worst-case scenario, but it has happened. **Cleanup from this event is both difficult and expensive.** With careful attention to the weather, incidents like this can be avoided. **Because this potential exists, it is very important to allow adequate time for the pavement to cure before a rain event.**

The other extreme is an absence of moisture. **In situations where the atmosphere is hot and dry, the water in the emulsion will evaporate prematurely and cause the emulsion to break before the aggregate is applied and rolled.** If the asphalt does not have time to bond to the aggregate before it breaks, the result will be loose aggregate. There have been cases where the asphalt broke so quickly that no traces of asphalt were evident on the individual pieces of the aggregate applied to the road. Hot and dry weather patterns also reduce the moisture

content of the aggregate in the stockpiles. The ability of the asphalt to bind to the surface of the aggregate is reduced when the aggregate is excessively dry. The bond becomes localized to the first point of contact rather than coating the entire surface of the aggregate face. **Water has to be infused into the aggregate at the stockpile to help prevent this problem.** However, care should be taken not to saturate the aggregate to the point of free water flowing onto the pavement. **Ideal condition of aggregate is saturated surface dry (SSD).**

Temperature

Temperature can also affect a Chip Seal. **The AST Special Provision requires the air and surface temperature to be 50 degrees Fahrenheit and rising but not to exceed 98 degrees Fahrenheit and rising.** The temperature, like the moisture, affects the breaking of the asphalt and the subsequent bond which can be achieved between the emulsion and the aggregate. Even if everything is done perfectly, a day which is too hot or too cold can have disastrous effects on a Chip Seal. **When temperatures are below 50 degrees Fahrenheit, the asphalt will cool too fast and when the cold aggregate is applied, it will not bond to the emulsion properly.** Water is often trapped within the bond between the aggregate pieces, and the bond of the new pavement to the existing roadway. The Chip Seal appears somewhat intact but freezing temperatures will cause the aggregate to shell off in the weeks ahead because of the trapped water around the bond. **Excessive heat has the opposite effect on the emulsion. Moisture retention is not a problem, but the emulsion stays liquid too long and the bond never correctly breaks.** The asphalt tends to migrate to the top of the aggregate and bleeding will occur. If traffic is placed on the road too soon, tracking of the asphalt will certainly take place. **Furthermore, if allowed to eventually cure, the excessive asphalt on top of the Chip Seal will cause bleeding and make the pavement very slick.**

7. Traffic Control and Safety

The safety of the work crew and the traveling public is always the top priority. The Chip Seal process is fast moving and often spread out over a half mile on a secondary road. Ensuring the safety of workers and the traveling public can therefore be challenging. This chapter will discuss both the safety of the worker and the roadway user.

Chip Sealing operations involve big pieces of equipment moving up and down the road in close proximity to each other. **The equipment travels in reverse as much as it does forward.** Rollers must make multiple passes on the road, so they will be required to back over lanes just traveled. Soft or low shoulders can also be a potential problem for rollers if care is not taken when rolling the edge of the roadway. Workers must pay careful attention to their surroundings to avoid collisions.

The dump trucks will have to back into the spreaders and be pulled down the road in reverse. The pinch point between the spreader and dump truck is a potential for injury so crew members should use extra caution around the hitch and tailgate of the dump truck.

Workers are also required to do hand work around intersection radii and narrow sections of cul-de-sacs where they could be hidden or not seen due to the equipment. The distributor and roller should never occupy the same spot as the work progresses down the road. Good practices for worker safety include being aware of the potential accidents at the work site and maintaining awareness of the locations of each part of the Chip Seal Treatment train. The crew's understanding of the Chip Seal treatment sequence is very important to the success of the job and safety of the workers.

Another potential safety concern is overhead power lines and tree limbs hanging over the road. One of the primary responsibilities of the belt operator is to keep the raised beds of the dump trucks from hooking power

lines and trees, dragging them down on the trucks or onto the spreader. The risk of electrical shock or injury from falling limbs can exist if the trucks are not lowered in time as the train proceeds down the road. The spreader operator can assist in pointing out hazards, but the belt operator controls the dump truck operations while the trucks are connected to the spreader.

Chip Seal operations also pose a potential hazard to the traveling public. Drivers do not understand the Chip Seal process and they do not want to be inconvenienced. It can confuse travelers when the construction sequence is spread out over a section of the road. Once travelers pass one part of the operation, they often believe it is finished only to run up on another group of workers. For this reason, a pilot car with flaggers on each end of the work zone is required.

The Manual on Uniform Traffic Control Devices (MUTCD) typically restricts the work zone to two miles. Anything in excess of this often creates large cues of backup while the pilot car is making its laps. The volume of traffic using the road as well as number of intersecting roads within a given map can cause the work zone to be lengthened or shortened. The ability to store traffic on either end of the work zone can also factor into the overall length. Higher volume intersections can prevent the safe storage of traffic while the Chip Seal Treatment train is working.

Signing is required on each end of the work zone. Advanced signing advising "Road Construction Ahead," "Prepare to Stop," and "Flaggers Ahead," are required. Signing along the road being paved advising a temporary reduction in speed to 35 MPH with warnings of unmarked pavement and loose rocks is also required. Refer to AST signing detail which should be in the contract documents.

The distributor, spreader and dump trucks are required to complete their pulls into the intersection, so traffic will need to be stopped temporarily while the equipment is present at intersections. Care should be taken at intersections and the need of additional flaggers to handle traffic while the intersections are being paved may be required.

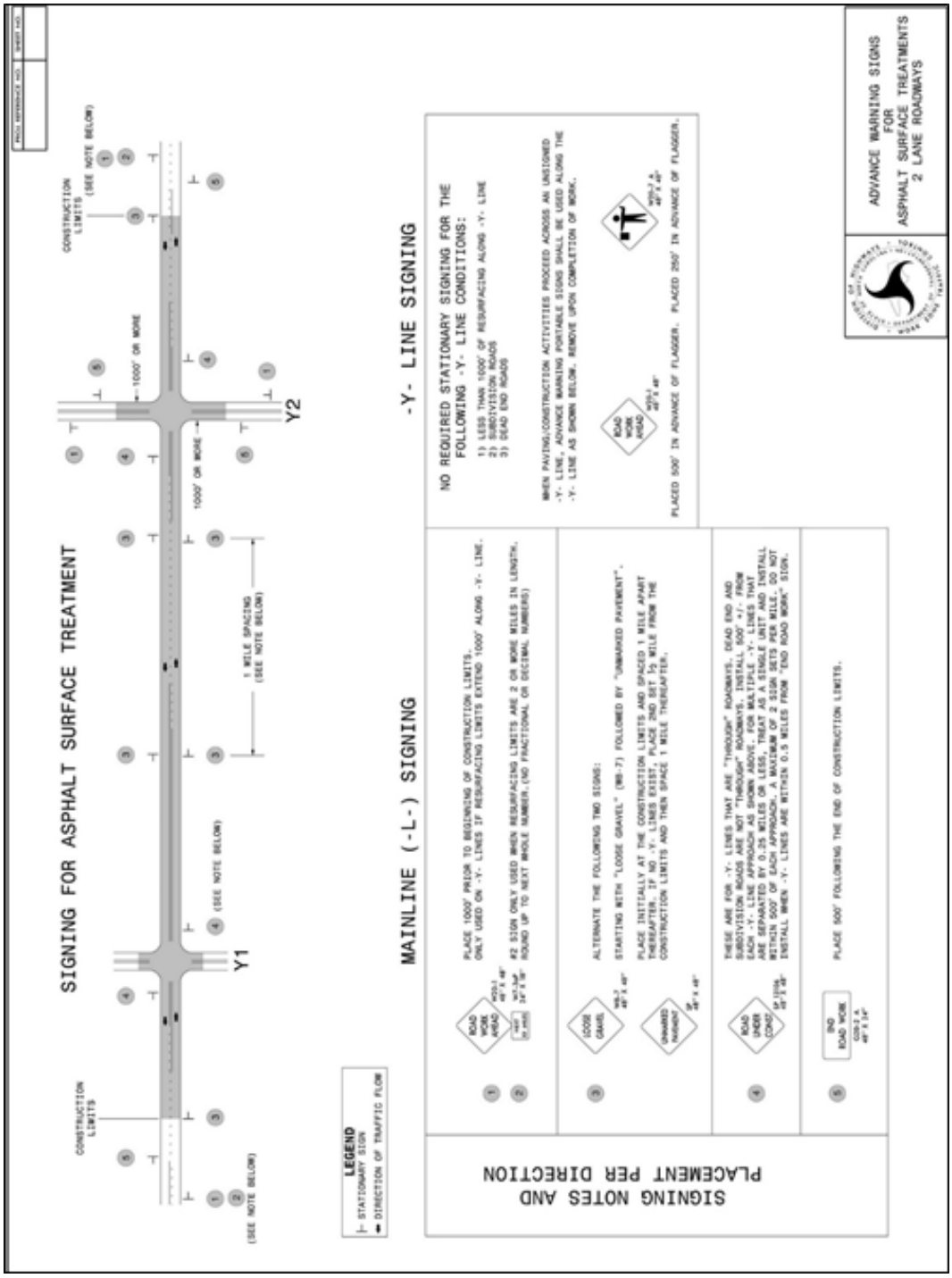
A key component of the ultimate strength of the Chip Seal is the curing of the pavement. Time must be allowed for the emulsion to break and for curing to begin before traffic is allowed back onto the completed section. Depending on the weather conditions, amount of traffic and type of seal, the curing time will vary. Traffic control must be maintained to prevent the motoring public from dislodging the aggregate before it has time to cure. A pilot car should be used to help maintain speed of the motoring public and to keep them off the newly paved section of road while it is curing. Also, care must be given to prevent aggregate haul trucks from creating the same dislodging of the aggregate as they haul aggregate to the spreader.

Key Notes

- **Pilot Car**
  - **Travel speed: 15 MPH.**
  - **Drive even slower when passing construction equipment.**
  - **Make every effort to keep traffic off freshly placed seal to avoid aggregate loss allowing for emulsion curing time.**

- **Flaggers/Communication to Public/Clear Directions**
  - **Maintain clear communication between each other (radios).**
  - **Location of flagger key is sight distance. Evaluate both horizontal and vertical sight distance.**
  - **Storage of traffic by flaggers.**

Figure 7-1. Asphalt Surface Treatment Signing.



8. The Processes and Sequences

Once the traffic control is in place, the existing road is prepared, and the pavement design is known, it is time to begin placement of the Chip Seal. In its simplest form, the Chip Seal is a layer of asphalt and a layer of aggregate spread evenly over the road and rolled. This series of asphalt and aggregate applications will happen one, two or three times; thus the names Single, Double or Triple Seal. Provided the weather conditions are favorable, the asphalt and aggregate rates are adjusted, and the existing road preparations are complete, the success of the Chip Seal depends on the timing of the following processes.

As with most construction practices, there can be numerous ways to achieve the same quality product. This chapter details one of these acceptable construction practices for Chip Seals.

Single Seal

The asphalt distributor will begin on the far-left side of the road, covering half the width of the roadway. The operator is seated on the left side of the distributor, so their line of sight is most accurate on the left side of the distributor. To ensure the left edge of the road has full coverage, the distributor applies the emulsion over the length of the first pull. Depending on the length of the road to be paved, the distributor might complete one side of the road or it could have to stop before reaching the other end. In either case, this completes the first pull, and the distributor must wait on the final two processes (the stone spreader and the rollers) to catch up before proceeding.

Immediately behind the distributor is the stone spreader. Like the distributor, the aggregate spreader operator is seated on the left side of the machine. The spreader will follow behind the distributor pulling a dump truck down the road. The spreader operator must align the left edge of the spreader gate with the edge of the emulsion which was just placed and align the right side such that it covers all but a few inches of the centerline joint. The spreader will continue until it catches up to the distributor. In the case where the distributor cannot reach the end of the road, the spreader needs to stop a few feet short of covering up the completed emulsion application of the first pull. Whenever the distributor cannot complete a pull, a joint will be introduced in the pavement. Care should be taken to minimize the number of joints along a section of road. When joints do have to be placed, the distributor will have to back up over the first application of emulsion and overlap the joint by a few feet. Only the emulsion can be overlapped. If aggregate is applied, it will cause a hump or bump in the road. In essence, there are two lifts of emulsion in this short section in the vicinity of the joint. This area sometimes has the tendency to bleed. Reducing the number of joints provides a better appearance and avoids excessive asphalt along the road which is the desired construction method.

The pneumatic tire rollers follow the spreader. One roller will begin on the edge line being careful to seat the aggregate all the way to the edge of the road, and the other will begin on the centerline and seat the aggregate all the way to the center. When the rollers catch up to the stone spreader or proceed about half way down the mat, one roller will continue on following the spreader and the other one will double back. The roller that doubles back rolls the edge line back to the beginning and the centerline coming back to the point where the rollers parted ways. The rollers continue making two passes, alternating forward and backward rolling down the road. The steel wheel roller will make one pass on each side of the road to complete the Chip Seal. Research has proven that three passes on a Single Seal is the most effective seating effort and provides adequate realignment of the aggregate without crushing. These three processes must be completed before the emulsion breaks, so the Chip Seal Treatment train must stay in close proximity to each other. Traffic must remain off the new pavement while the Chip Seal cures. The use of a pilot vehicle to maintain slow speeds on the new pavement will help in this process.

The Chip Seal Treatment train can now return to the beginning of the road and pave the other side in the same way. Returning to the beginning point will allow both the distributor and spreader operators to have the best view of the centerline joint. On the second and final pull, the distributor will lap the centerline joint where the spreader omitted placing aggregate on the first pull. The spreader will place aggregate slightly over onto the first pull and all the way to the right edge of the pavement. This provides complete centerline coverage and helps prevent raveling along the longitudinal joint between the two sides of the road. The pneumatic tire rollers and the steel wheel roller proceed as on the other side. A final common practice that strengthens the centerline joint is to have the steel wheel roller make a final pass straddling the joint after all the required passes have been completed. While the right lanes are being placed, the pilot vehicle and supply trucks need to travel slowly reducing the chances of dislodging the aggregate. Care should be taken not to back up, turn sharply or apply heavy breaking on the new pavement while it is still curing. (See Figure 8-2, page 29)

Double Seal

The process for the Double Seal begins just like the process for the Single Seal. However, after the first pull, rather than coming back to the start of the road, the second pass is made in the reverse direction. The distributor and stone spreader turn around at the end of the first pass and apply the second coat of emulsion and aggregate on top of the recently-placed bottom layer.

The rate of application of both the emulsion and the aggregate will be different for the second pass, so the adjustments need to be made to the equipment before the second pass begins. In addition, some mixes require a different size aggregate on the top lift. If this is the case, refer to the Modified Double Seal and follow those procedures.

The second lift must be applied before proceeding to the other side of the road. The bottom lifts cannot all be applied before the top lifts are applied because too much time would pass, and the emulsion would break. The bottom layer needs two passes by the pneumatic rollers before the second application of emulsion and aggregate. After the second application, the combination and pattern of rollers used on the Single Seal can then finish the rolling. A total of six passes by the rollers will complete the first pull, three on the bottom lift and three on the top lift.

As with the Single Seal, the centerline joint must be offset to prevent excessive buildup of materials in the middle of the road. At no time can aggregate be placed on the roadway without the presence of emulsion under it. The absence of emulsion will cause the aggregate to ravel off, leaving a pothole in the pavement. The first layer of aggregate, and the second layer of emulsion and aggregate can be placed in the same plane, not allowing for any stepping over of the material when the adjacent lane is being paved. To ensure the quality of the centerline joint, the first layer of asphalt needs to extend about four inches out from under the first pull. When the equipment has finished the left side of the road, it is in position to switch to the right lane. When the first pull of the right lane is complete, the equipment must return to the start of the right side and proceed down the road completing the second pass. The final pass needs to be pulled with the centerline joint on the left side of the Chip Seal treatment equipment. This prevents the distributor, spreader or dump trucks from tracking the new pavement, and allows the operators the best sight line to the centerline joint. (See Figure 8-3, page 30)

Double Seal (Modified)

The Double Seal processes above describes the lay down of like size aggregates. In the event the specifications call for different size aggregate in the Double Seal, the process should be modified as follows. Rather than completing one side of the road then switching to the other side, each layer of the same size aggregate is placed then rolled. Each lift of emulsion and aggregate must be rolled three times due to traffic being placed on the incomplete seal following the Single Seal Rolling pattern. The size of aggregate will decrease in the upper lifts for the Modified Double Seal. The second lift of aggregate will decrease in size, therefore requiring the need to modify the placement of the Chip Seal. Mixing a smaller aggregate in the underlying seal will tend to cause the road to bleed. Keeping the different size aggregates separated is always a good practice and requires the spreader to be cleaned out when aggregate size changes. (See Figure 8-4, page 31)

Triple Seal

The first two passes for the Triple Seal are just like the Double Seal. Both layers are rolled as before and, upon completion of the first two passes, the distributor and spreader turn around and proceed down the adjacent lane leaving the third pass for later. The bottom two lifts are applied to the adjacent lane being careful to stagger the centerline joint on the first two passes. Once the bottom two lift of the Triple Seal are complete, the third lift can be applied to both lanes. The centerline joint should be placed in the middle of the road on the final pass. The final pass is pulled from the edge line. Attention must be paid to the rates and type of aggregate placed on each lift. (See Figure 8-5, page 31)

Figure 8-1. Chip Seal Types.

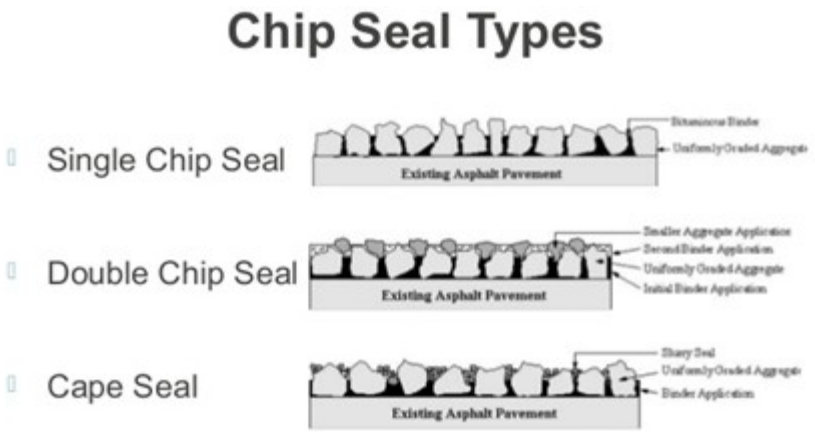


Figure 8-2. Single Seal Paving Sequence.

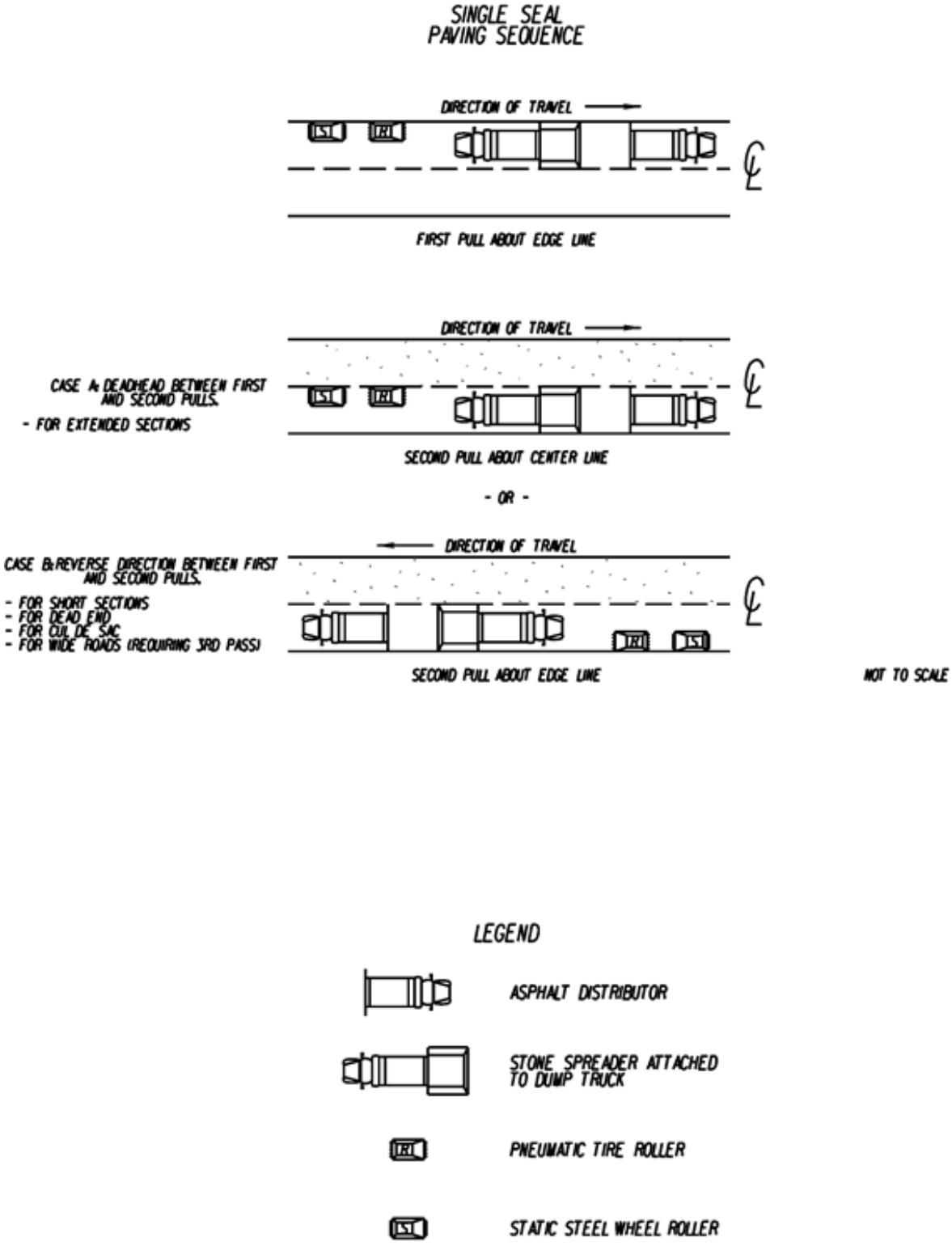


Figure 8-3. Double Seal Paving Sequence (Same Sized Aggregate).

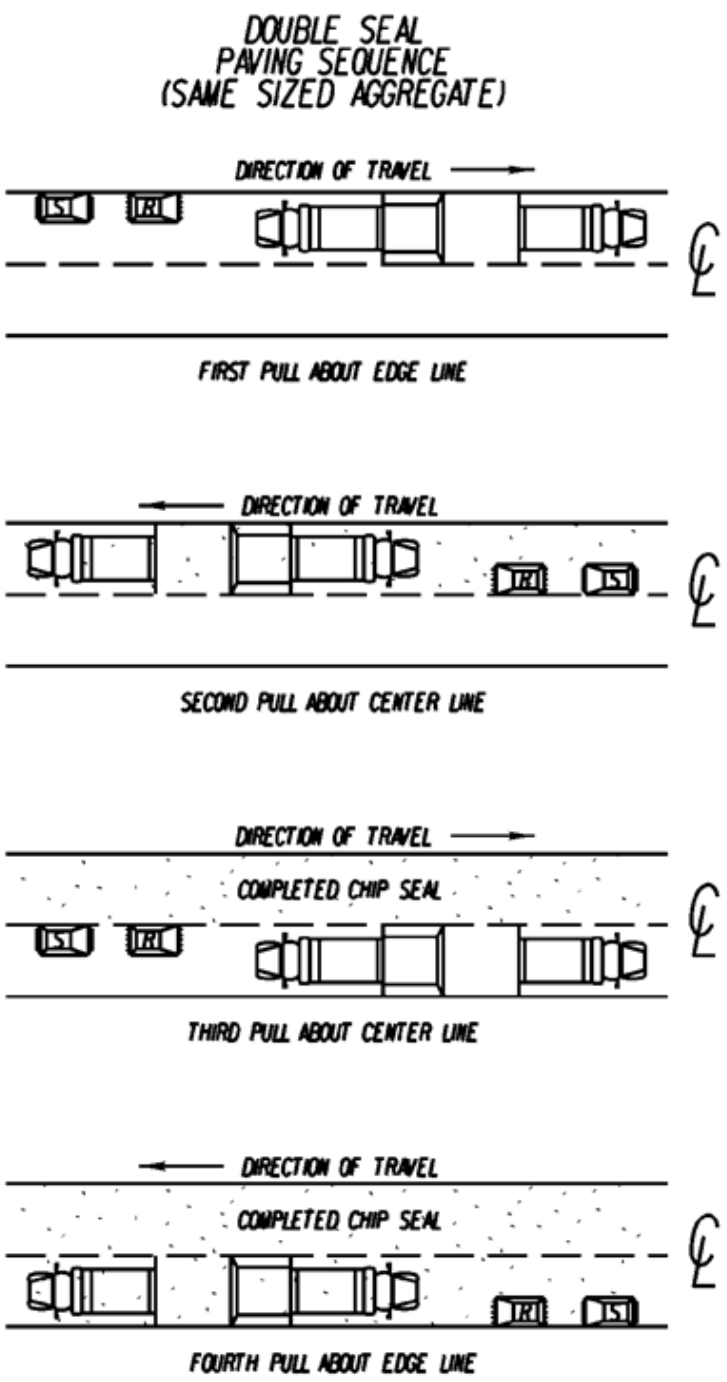


Figure 8-4. Modified Double Seal Paving Sequence (Different Sized Aggregate).

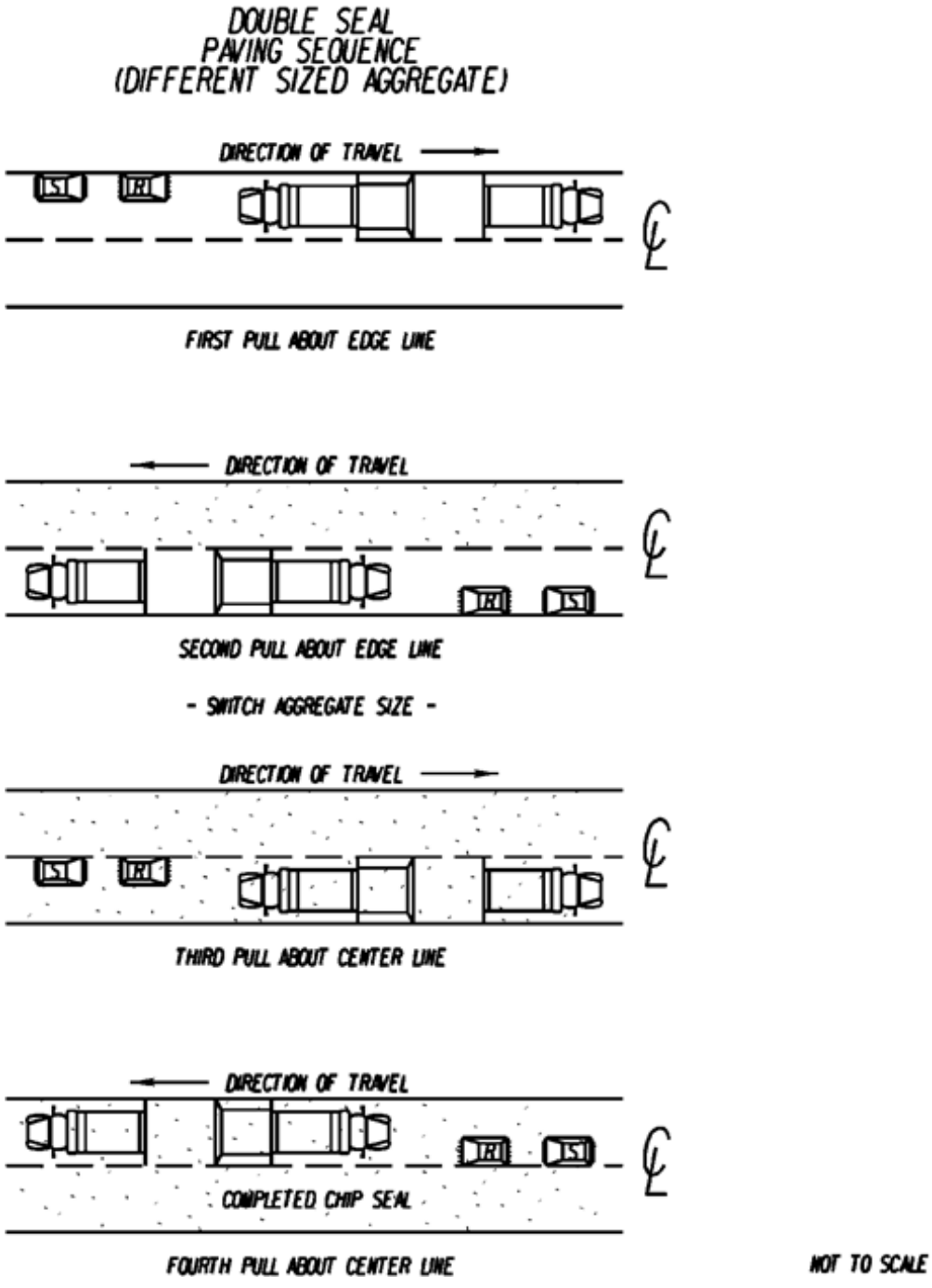
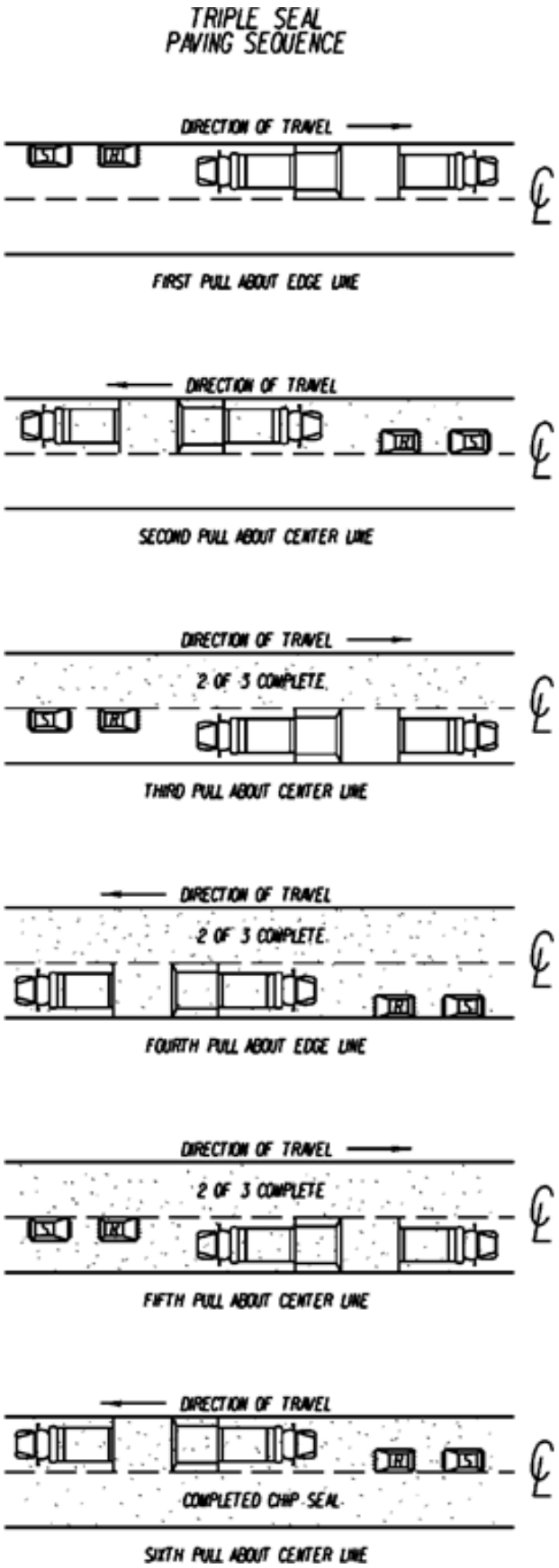


Figure 8-5. Triple Seal Paving Sequence



9. Proper Rolling Practices

Given the particularities of placing emulsion and aggregate on the roadway, the ultimate strength of the pavement can be maximized during the first few hours in the life of the pavement by understanding "Art of Chip Seals." Assuming the materials are placed properly, the factors which will determine the success of the Chip Seal are the condition of the existing pavement, the rate and volume of traffic which is allowed to immediately travel on the new pavement, and how well the new pavement is rolled. Although the existing condition of the road is a factor of the ultimate strength of the Chip Seal, as discussed in Chapter 2, it is independent of the proper procedures for placing a Chip Seal. Traffic volume added to the newly paved road is discussed in Chapter 7. The remainder of Chapter 9 will concentrate on the proper rolling practices.

Rolling allows for the realignment of the aggregate within the mixture, removing excessive voids, and providing closer bonding planes with the old pavement and the individual pieces of aggregate. Research by the NCDOT and North Carolina State University has shown the pneumatic tire roller is the first roller needed in the rolling process. The independent wheels on the pneumatic roller allow for maximum contact with the aggregate and emulsion to the existing pavement. Given the types of emulsions used for Chip Seals, the passes by the rollers need to be within three to five minutes of the aggregate spreader. Two passes by the pneumatic roller need to be completed on the final lift for each type of seal followed by the steel wheel. For underlying lifts, at least three passes should be made on each lift.

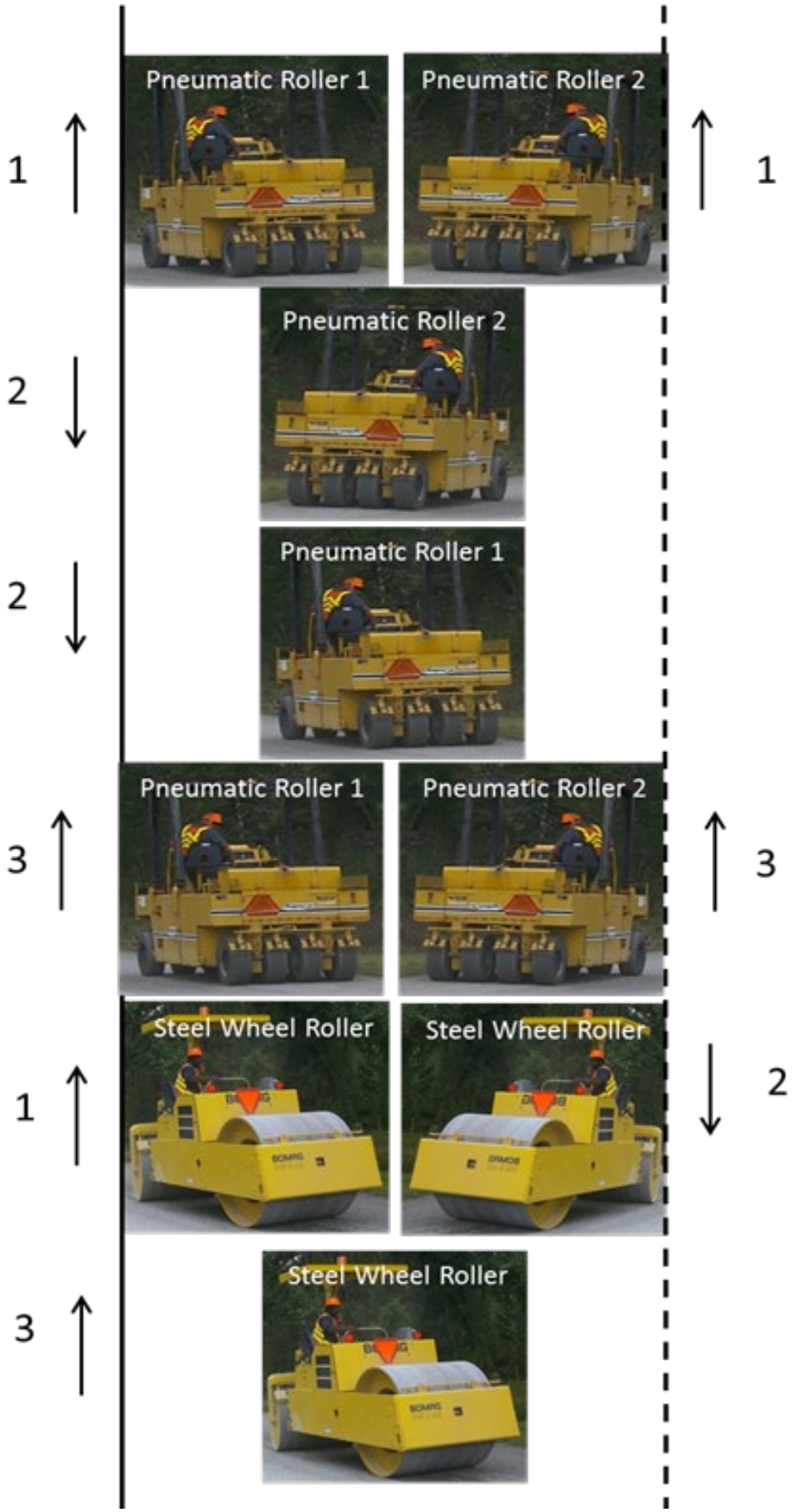
The steel wheel roller must follow the pneumatic tire roller. Even though the steel wheel will not vary with the contour of the road, the use of the steel wheel will actually provide a smoother ride. The final lift is required to be made by the steel wheel roller. The use of the combination roller in place of the steel wheel is permitted and will increase the aggregate retention on each of the pavement types.

The total number of coverages for a Single Seal is three: the first by the pneumatic tire roller and the third by the steel wheel roller with the second pass being completed by a combination of the two rollers. Each successive lift is rolled in the same manner so the number of complete coverages for a Double Seal is six and for the Triple Seal is nine. Remember, to obtain a complete coverage two or three passes by each individual roller may be required depending on the width of the pull.

Figure 9-1. Asphalt distributor followed by the stone spreader and roller.

Figure 9-2. Two pneumatic tire rollers followed by a static steel wheel roller.

Figure 9-3. The rolling sequence on the first side of the road.



10. The Varying Rates

Chapter 5 of this manual includes the current AST Special Provision to be used in all NCDOT contracts effective March of 2015. These specifications give the Divisions the ability to assign the type of emulsion and aggregate to be used on the roads being advertised. These guidelines allow for the adjustment of the emulsion rates due to the condition of the road. The new specifications allow for a 0.03 gal/yd2 tolerance limit in the various lifts of emulsion placed on the road. Years of experience have shown the rates noted in the new specification will deliver a Chip Seal that is neither too rich in asphalt, which causes bleeding, nor too lean in asphalt, which results in loose aggregate. The rates provided will serve well in most cases. Divisions do have the authority to specify a specific rate other than what is provided for in the AST Special Provision. When necessary, the contract will specify a specific rate to be used. The other procedures described in this manual would still be applicable, including the 0.03 gal/yd2 tolerance for emulsion.

If the existing road is bleeding or oxidation is present, the initial rate of asphalt must be adjusted. The 0.03 gal/yd2 tolerance allows for this adjustment in the rate. Any additional emulsions added to the pavement do not need to be adjusted and should be shot at the rate provided. The common issue in most of today's pavement is oxidation, which requires additional emulsion added to the first pass. Emulsions available in the last few years tend not to bleed as they once did when the cutback asphalts were commonly used. The additional asphalt applied to an oxidized pavement provides a better bond between the existing road and the aggregate. In the rare case where the existing road is bleeding, the reduction in asphalt will prohibit the asphalt from working up through the aggregate and perpetuating the bleeding problem.

Figure 10-1. Example of a bleeding road.

Figure 10-2. Example of an oxidized road.

Figure 10-3. Example of a road with excessive bleeding.

11. Construction Issues

The Chip Seal produces an excellent pavement when all the necessary factors come together. Although the materials needed for a Chip Seal are simplistic, a finesse and understanding of how these materials are handled, applied, and allowed to cure is required if the seal is going to be effective. This is the "Art of Chip Seals," and it must be understood for the success of the seal. Excluding the material handling issues covered in Chapter 4 and weather conditions covered in Chapter 5, problems which typically arise during construction are related to the application of the materials, the timing or sequence of their placement, and the rolling or curing of the pavement. This chapter will offer guidelines to avoid the commonly observed issues in Chip Seal Construction.

Insufficient Emulsion

Insufficient or excessive material being applied to the roadway is a common problem which can be caused by the abnormal operation of the equipment or by human error on the equipment. The asphalt distributor and the function of its components are the primary causes of insufficient emulsion being applied to the roadway. **Typical signs of improper emulsion application will appear in the form of streaking.** Streaking occurs where the emulsion is not sprayed at a uniform rate across the mat. There will be excessive amounts of emulsion applied adjacent to lean amounts of emulsion. When this is observed, the first step in trouble shooting should be to ensure the emulsion is at the proper application temperature. Attempting to apply a cold emulsion or one that is over-heated in the tank will cause malfunctions in the pressurized nozzles. In addition, emulsion should not be over-heated, or the asphalt will break. It is very important to maintain adequate circulation, and the emulsion must not be allowed to break in the spray bars. The omission of emulsion or a non-standard rate of emulsion will cause the aggregate to shell or come off as soon as traffic is allowed to run on the pavement. This loss of aggregate in a Chip Seal pavement is called raveling, and it will create potholes in the final surface. A clogged nozzle or an improperly positioned spray bar will also cause this problem. Attention to the spray pattern of the distributor is of utmost importance.

It is also important to cover the entire width of the pull with the distributor. Care should be taken to ensure the edge of the pavement is covered and pulls are straight along the edge and are slightly overlapping any previous pull when applying Chip Seal Treatment to adjacent lanes. These practices ensure there will not be any voids in the asphalt layer, which is critical to keep the aggregate from shelling off. Double and Triple Seals require the centerline of the road to be sprayed multiple times. Care should be exercised to cover the joint with the emulsion without an excessive buildup of asphalt and aggregate at the joint. Insufficient emulsion can also be caused by equipment or vehicles riding on the mat prior to the placement of the aggregate. Vehicles can contaminate the asphalt layer or pick up the material causing these voids. For this reason, the asphalt distributor and stone spreader should remain as close as possible. Offsetting of the longitudinal joint of Double and Triple seals will prevent premature failure of joint.

Key Notes

- **Emulsion may be too cold or too hot. Maintain 160 to 170 degrees Fahrenheit.**
- **Embedment depth of aggregate matters. Too little results in premature aggregate loss. Too much results in submerged aggregate which results in bleeding, loss of skid resistance.**
- **Overlap in emulsion pulls to ensure aggregate bond along joint.**

Figure 11-1. Example of insufficient emulsion.

Excessive Emulsion

Unlike raveling, which occurs when there is insufficient emulsion in an asphalt mat, bleeding is the problem which occurs when excessive asphalt is placed on the road. This can be because of the amount of residual asphalt on the existing roadway or the application of too much emulsion at the time of Chip Seal Treatment. Chapter 10 deals with the varying application rates and how they are related to concerns associated with the existing roadway. Excessive amounts of emulsion placed at the time of Chip Seal Treatment are normally a result of the improper handling of the asphalt distributor. The fact the entire surface area of the roadway must be sprayed to avoid aggregate loss requires the distributor to fully coat the surface with emulsion. **Total coverage of the surface with emulsion means there will be locations where the emulsion will overlap. This is required if the Chip Seal is going to perform correctly. Care should be taken to minimize the overlap.** Typical problem areas along the road are at intersection radii, centerline joints, and in cul-de-sacs or turnarounds. Special care should be taken to avoid over spraying in these locations. **The use of the hand wand in these odd shaped sections will reduce the chances of over spraying the asphalt mat. Another problem area tends to be at the joints that form when the distributor must stop and start during Chip Seal Treatment.** The ability of the stone spreader and dump trucks to keep the Chip Seal Treatment train close to the distributor goes a long way to preventing this issue.

Figure 11-2. Example of excessive emulsion.

Insufficient Aggregate

As with the emulsion, aggregate can often be applied too liberally or too conservatively during the Chip Seal Treatment process, even when the rates are correctly adjusted. The majority of the problems arise from the operation of the stone spreader. Insufficient aggregate coverage can almost always be traced back to the spreader. As described in Chapter 3, the spreader has two hoppers, one on each end of the machine. The rear hopper is where bulk aggregate is delivered to the spreader. Failure to keep aggregate adequately supplied here will cause the front hopper to run out. In addition, the front hopper must be continually fed by the belts or it will run out. Without this constant supply of aggregate and the front gates open, the spreader will travel down the roadway and leave gaps in the stone mat. It is extremely important for the belt operator to keep the front hopper full. Sometimes, the gates on the front hopper will clog up, even with a constant supply of aggregate. Debris can be a cause of clogging, so it is important to ensure the aggregate is clean and free of debris. Often, debris can be introduced in the aggregate as a result of poor stockpile management. Whatever the cause of insufficient aggregate coverage, allowing voids in the aggregate will cause the emulsion to be uncovered, which can cause bleeding or become tracked by other equipment. This can create a problem during construction and certainly can reduce the life of the pavement.

Figure 11-3. Example of insufficient aggregate.

Excessive Aggregate

The most common concern with the aggregate is an excessive amount on the road due to spillage. Spillage can come from the spreader or the dump trucks which supply the spreader. When excessive amounts of aggregate are spilled onto the asphalt mat, the locations will always shell off leaving potholes in the final profile of the road. The emulsion cannot bind the extra aggregate, and when traffic is allowed to travel on the road the loose material will pop off leaving a void in the pavement surface. Even if multiple seals are applied, the loose aggregate will eventually shell off.

Figure 11-4. Example of excessive aggregate.

Wash-Boarding

On rare occasions, wash-boarding is a problem for Asphalt Surface Treatments. Wash-boarding is a defect in the surface of a Chip Seal which is usually felt more than it is seen. It is a series of ripples placed in the pavement by the spreader and is a result of uneven aggregate spread. If the spreader's forward travel speed is too fast, the spreader will begin to bounce or jump and the aggregate will fall out of the hopper. When this happens, the aggregate will alternate between being heavy for a few inches and then light for a few inches. This cycle will continue repeating itself until the spreader is stopped and forward speed is reduced. The result is an uneven distribution of the aggregate and ripples across the lane width. Poor patching or rough existing pavement profiles can also cause this problem. As mentioned in Chapter 2, Chip Seals are a uniform thin lift of emulsion and aggregate, so any discrepancy in the original profile of the road will be promoted up through the new pavement and the road will have consistent shape characteristics with the existing road.

12. Common Practices

Operator Orientation

The most advantageous pulls for the distributor and spreader are from the left-hand side. The operating positions on this equipment are on the left side, so the operators have a clear view of the edge or joint to which they are aligning the new pavement. It is difficult to properly align the right side of a pull up to a fixed location. Doing so is called "shooting blind," and has the potential of leaving gaps or over-placing materials on the road. For this reason, most critical pulls are done allowing the operator the best view possible. These pulls are typically the first and last pulls of a section of road. In the first pull, the operator makes sure the material completely covers the left edge. The last pull ensures the centerline joint is matched without leaving gaps or placing excessive material on the road.

Longitudinal joints or centerline tie strips require special care when they are constructed. If allowances are not made for the overlapping of emulsion and aggregate the potential for multiple layers of material to build up on the centerline exists. This overlap of material will cause an exaggerated bump in the road. To prevent this, a common practice is to cut off the outside gate of the aggregate spreader leaving two or three inches of emulsion exposed without placing aggregate on top of it. When the adjacent lane is constructed, the emulsion is lapped onto the exposed emulsion, and then aggregate is placed on top of the two layers of emulsion. Bleeding does not typically occur here because the outside nozzle doesn't receive double or triple coverage. In other words, it takes two passes by the outside nozzle to receive double or triple coverage.

Figure 12-1. Example of centerline tie strip or longitudinal joints.

Removal of Excess Aggregate

As noted in Chapter 3, sweeping or vacuuming is required to remove excessive aggregate when the roadway has cured after completion of the Chip Seal Treatment. Curing typically takes between three to seven days, depending on weather conditions and the amount of traffic using the road. When temperatures remain high through the days and especially the nights which follow Chip Seal Treatment, the asphalt will take longer to cure. It is a good practice to wait until the pavement has settled down before brooming. Often, it is best to sweep early in the day before temperatures rise again. Higher traffic volumes sometimes require the Chip Seal to be broomed before this time frame. In these circumstances, brooming the road early in the morning very lightly can also help with the loose aggregate. A vacuum truck is an alternative method for situations like this or in situations where development along the roadway will not allow for brooming the aggregate onto the shoulder. Vacuuming allows the loose aggregate to be picked up without using the brooming action of the mechanical broom. Furthermore, using a vacuum truck will prevent dislodging any additional aggregate and help reduce the aggregate from collecting in yards and driveways of adjacent property owners.

Blotting Sand

As noted in Chapter 6, weather conditions play a major role in Chip Seal placement. Some crews will carry blotting sand on their supply truck to be used on concrete driveways if the potential exists for asphalt to run down the driveway. Afternoon showers can sometimes appear unexpectedly and cause the asphalt in the emulsion to run off the road. Sand dikes or breaks can redirect the water to the grass around the driveway. Blotting sand can also be applied on the surface of the roadway should the asphalt puddle, or if there is a concern about runoff present.

Intersections

Intersections and radii at the beginning and along the map being paved are always a challenge for traffic control and operations. Most often, they have to be done by hand and require personnel on the ground. The emulsion is normally applied with the spray wand on the distributor and the stone is spread by hand out of the back end of the spreader. These activities must be completed before the final pass of the main line seal. It is common practice of the NCDOT to pave with plant mix asphalt for the intersections. Plant mix asphalt is the pavement type for higher volume secondary roads. Where this is the case, most maps will begin and end at the termini of the intersections. These locations do not need to be resurfaced unless directed by the engineer or specified in the contract. Care should be taken to not over-apply any of the material.

Construction Vehicle Management

The supply of materials to the Chip Seal Treatment train is vital to the ongoing production of the Chip Seal Treatment crew. Distributors and dump trucks will make numerous trips back and forth to loading areas to resupply the Chip Seal Treatment train. If care is not taken, the heavy vehicles, multiple trips and frequent turnarounds will dislodge the aggregate even after it has been rolled. The ultimate strength of a Chip Seal is developed from the time the rolling is completed through the time it takes to cure. Quite often, the heaviest loads the surface will bear are the construction equipment, which makes it the most likely to damage the newly paved surface. To that end, the operators of these pieces of equipment need to use caution as they perform their duties. Where possible, operators should avoid turning around on newly constructed Chip Seals. They should stagger their tire tracks across the lane by riding on the far left or far right on the lane lines to avoid the wheel paths. They should also space themselves out over the entire section to be paved and avoid any unnecessary trips. Their travel speed should be reduced to prevent unnecessary aggregate being dislodged.

13. Inspections and QC/QA

Inspection

The NCDOT will provide inspectors for the placement of all Chip Seal Treatment work within the Divisions. Their function is to ensure compliance to all specifications contained in the contract and standard specifications. They also are required to complete the AST Daily Report to obtain quantities for pay items included in the contract. The completion of their work helps ensure both quality of work accomplished and accuracy in materials placed for pay items. Understanding their role is also important to the overall success of the project.

Typical areas of concern are the same for both inspectors and contractors, and are as follows:

- Weather – temperature and rain
- Calibration – 100-foot test section
- Cleanliness of roadway
- Total square yards to be paved
- Temperature of emulsion
- Application rate of emulsion
- Amount of emulsion used
- Square yards of aggregate placed
- Timeliness of emulsion and aggregate laydown
- Timeliness of rolling
- Proper Signage and Traffic Control
- Quality of both emulsion and aggregate

Each of these items have been discussed in the manual, so a general understanding of potential issues will help ensure a successful project. Attention to the details in weather, temperatures, road preparation, and uniform applications are the general observations which can be made before and during laydown. The quantities of materials used can be easily calculated at the conclusion of each lift and verified against the application rates being used that day. The Daily Report will help direct the calculations and eventually calculate the pay items for each map. It is recommended an AST Daily Report be done on each map completed even if multiple maps are completed on one day. If the map requires multiple days, then multiple Daily Reports would be required for that particular map.

Figure 13-1. An AST Inspector's Daily Report.

M-T Form 660 4-6-2015

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

ASPHALT SURFACE TREATMENT (AST) INSPECTOR'S DAILY REPORT

Project No.: _____ County: _____ Div. _____ Report No. _____

Date: _____ Weather: _____ Temp. High: _____ Low: _____

Type of Construction: _____ Route No. _____ Miles: _____

Map Proj. No.: _____ Map No.: _____ Map Length _____

Contractor (Prime): _____ AST Contractor: _____

EMULSION DISTRIBUTOR			AGGREGATE SPREADER			SWEEPING EQUIPMENT			
No.	Make	Speed	No.	Make	Speed	No.	Type	Date of Initial Sweeping	Comments

ROLLING EQUIPMENT					SIGNAGE	
No.	Type	Weight	Tire Pressure	Speed	Date of Signage Installation	Date of Signage Removal

EMULSION							AGGREGATE		
Source	Grade	Beg. Gal.	End Gal.	Gal. Used	Delivered Temp	Placed Temp	Source:		Placement comments:
							Stockpile:	Yes / No	
							Location:		

MATERIALS PLACED TODAY

Seal Type	Stone Type	Emulsion Type	Layer	Uniform coverage: Y or N	Base Type (Soil, AST, Mix)	Beg. Mile Post	End Mile Post	L.F.	Lane Width	Sq. Yds.	Lbs. Of Agg. Per Sq. Yd.	Gal. Of Emul. Per Sq. Yd.
								Total Miles (L.F./5,280)		Total Sq. Yds.	Total Lbs. of Agg.	Total Gal. of Emul.

Official Inspection: _____

Remarks: _____

*Print Rdwy Tech's Name: _____ RD1- _____ Res. Eng. _____

*Rdwy Tech Signature _____

*By providing this data under my signature and/or Hicams certification number, I attest to the accuracy and validity of the data contained on this form and certify that no deliberate misrepresentation of the test results in any manner has occurred.

Figure 13-2. The NCDOT Chip Seal Best Practices Checklist.

Chip Seal Best Practices Checklist

1. Has the Certificate of Compatibility been submitted for each Chip Seal type?
2. Has the existing roadway surface been cleaned and prepared for the Chip Seal?
3. Are weather conditions, air, and surface temperatures sufficient for Chip Seal application?
4. Are traffic control signs in place and is pilot car ready?
5. Have the Bills of Laden for the asphalt emulsion been received?
6. Has the Distributor truck been calibrated for this project?
7. Is the target rate of emulsion for each Chip Seal type known?
8. How will the gallons of emulsion be measured or determined?
9. Is the application temperature of emulsion between 160-170°F?
10. Does the Distributor spray a uniform lift of emulsion?
11. Is spray pattern free from streaks or heavy concentrations of emulsion?
12. Has the Aggregate Spreader been calibrated for this project?
13. Is the target rate of aggregate for each Chip Seal type known?
14. Has Aggregate Spreader been calibrated across the width of the Spreader box?
15. Does the Spreader apply a uniform lift of aggregate?
16. Is the aggregate clean and free from dirt, dust, or debris?
17. Are pulls covering the edge of road and centerline joints completely?
18. Is excess aggregate being removed before additional lifts are being placed?
19. Are the Pneumatic and Steel Wheel Rollers operational?
20. Are Roller coverages completed within 5 minutes of emulsion placement?
21. Is traffic being maintained through the work zone?
22. Are mechanical or other brooms in proper working condition?

Sampling

The certificate of compatibility serves as the primary tool before beginning work to ensure the NCDOT the materials supplied for the project are acceptable and will bond as required. The Materials and Tests (M&T) Unit inspects source materials on a regular basis without the need of project specific testing. However, should issues arise once the project has begun, the engineer has the ability to sample both the emulsion and aggregate to ensure the materials are within specification. The M&T Unit in Raleigh conducts testing for the Divisions and can be reached at 919-329-4000. The M&T Unit conducts periodic inspections of both emulsion and aggregate, but additional testing will be required in the event there is a performance issue in the field. The inspector can take samples of either the emulsion or aggregate according to M&T guidelines found in the Asphalt Emulsion Field Manual or aggregate gradation tests and send to the lab for additional testing.

Asphalt Emulsion sampling is governed by AASHTO T40. There are several tests which can be run but the ones that normally effect Chip Seals are the viscosity, penetration, elastic recovery, and particle charge. Failures by the emulsion on any of these tests could result in bleeding or aggregate loss, and ultimately the failure of the Chip Seal. These tests are described in the Asphalt Emulsion Lab Manual and can be obtained from the M&T Unit.

Aggregate gradation tests are described by AASHTO T27 and T11. Portions of both these tests are important to a successful Chip Seal. They give the sieve analysis and amounts of fine materials present in the aggregate. Aggregates failing either of these tests will cause aggregate loss and bleeding. The Asphalt Section of the M&T Unit can assist with these tests and can be contacted at 919-329-4060.

14. Summary

A quality Chip Seal will be achieved provided the attention to details is put into every aspect of its placement. Experience is the best teacher! There is no room for error in material handling, laydown workmanship and traffic control. Controlling all of these factors and following the procedures in this manual will aid in producing a successful project.

The use and handling of approved materials begins the process. Emulsions must be maintained within appropriate temperature ranges. Excessive heating and cooling reduces the ability of the emulsion to perform as desired. Aggregates must be clean and free from debris. Stockpiles must be kept separated and care should be taken by the loader to avoid digging too deep and contaminating the stockpile with unwanted material. Spreader boxes and distributor bars should be kept clean and free from debris. They should be periodically cleaned for optimal performance. Anything which restricts or reduces the uniform application of material will cause a problem. Documentation of emulsion suppliers, temperatures, application rates and aggregate sources will assist in controlling and knowing approved materials are being used.

Using the right material is effective, provided it is placed properly. Observation of the Chip Seal Treatment process is the best way to inspect this part of the work. The applications should be uniform across the road surface. There should not be gaps, streaks, or voids in the emulsion or aggregate. The rate could be correct but if the material is not uniformly placed, there will be problems. The Chip Seal Treatment train should not become spread out. The aggregate spreader should follow the distributor within approximately 500 feet, followed by the rollers within five minutes. Any foreign material or excessive aggregate piles observed should be removed before rolling. Observation of the process provides the best assurance that the Chip Seal is being properly placed.

Maintaining proper traffic control throughout the process is always of highest importance. For the safety of the traveling public, the crew, the inspector, and the effectiveness of the seal, traffic control must be in place from beginning to end. As work is completed and the equipment removed from the road, traffic control should continue to be deployed as traffic is allowed to resume travel at reduced speeds. Loose aggregate is inevitable. By helping control the speeds of the traveling public, the curing out process will be more effective and driver safety improved.

Asphalt Surface Treatment has been and will continue to be an excellent cost-effective treatment for the many miles of secondary roads maintained by the Department. The proven techniques developed over the years and the research studies recently completed only validate this approach to roadway maintenance. This Best Practices Manual coupled with experience gained by placing Chip Seal Treatments, will continue to serve the traveling public for years to come, all the while preserving the North Carolina Department of Transportation statutes as the "Good Roads State."

Appendix A

Table A. Material Application Rates and Temperatures.

MATERIAL APPLICATION RATES AND TEMPERATURES				
Type of Coat	**Layer**	**Aggregate Type**	**Aggregate Target Rate (Lbs./Sy)**	**Emulsion Target Rate (Gal/Sy)**
Single Seal	Top	78M	18	0.35
		5/16" LW	10	0.32
		#9	10	0.32
		CA-9 LW	10	0.35
Double Seal	Top	78M	12	0.25
		5/16" LW	9	0.25
		#9	9	0.25
		CA-9 LW	9	0.25
		#14	7-9	0.20
	Bottom	78M	18	0.30
		5/16" LW	10	0.30
Triple Seal	Top	78M	12	0.22
		5/16" LW	9	0.25
		#9	9	0.25
		CA-9 LW	9	0.25
		#14	7-9	0.20
	Middle	78M	15	0.24
		5/16" LW	9	0.25
	Bottom	78M	18	0.30
		#67	30	0.32
		5/16" LW	10	0.30
Mat and Single Seal	Top	78M	14	0.22
		5/16" LW	9	0.25
	Mat	#67	38	0.32
		#57	40	0.35
Mat and Double Seal	Top	78M	12	0.25
		5/16" LW	9	0.25
	Middle	78M	16	0.25
	Mat	#67	38	0.40
Mat Coat		78M	18	0.35
		#67	38	0.40

Appendix B

History: The "Art of Road Oil"

From the earliest days of the North Carolina Department of Transportation (NCDOT), Road Oil has played an important role in the maintenance of North Carolina's highways. What began as a practice of placing oil on soil roads has evolved to be the primary pavement surface on the majority of North Carolina's Secondary Road System. Although the technologies, equipment, materials and people have changed through the years, the affectionately assigned name has stayed the same: Road Oil. This manual represents over 70 years of progress since the early days of Road Oil. It is offered as a reference for a proven method of applying the "Art of Road Oil" to the backbone of North Carolina's roadway system.

Figure B. Road Oil in North Carolina in 1942, courtesy of E.D. Etnyre & Company.

For years, Asphalt Surface Treatments (AST), commonly called "Tar and Gravel," were limited to the pavements placed by the Road Oil Units throughout the 14 NCDOT Divisions. This practice was limited by the equipment and the materials available but did serve the NCDOT very well as a low-cost pavement surface. Today, Asphalt Surface Treatments have developed into numerous treatment types with various names, all under the heading of Pavement Preservation.

Asphalt Surface Treatments, specifically Chip Seals, in basic terms, consist of a layer of emulsified asphalt and uniform graded aggregate placed on the roadway and rolled. The type of emulsions and aggregates vary as does the number of layers, but each successive lift of asphalt and emulsion should be rolled in a timely manner to ensure aggregate retention. This Best Practices Manual was developed by the NCDOT to provide guidance for the proper placement of a Chip Seal.

Chip Seals provide several excellent benefits for the roadway, especially where the structural integrity of the base

is decent prior to resurfacing. It must be understood this treatment does not provide a real structural coefficient for the pavement, but it is excellent in providing a water-resistant barrier for the underlying pavement and base of the roadway. Given the lack of structural strength provided by the seal, it is important for the pavement to be adequately prepared before sealing. Chapter 2 in this manual is dedicated to pavement preparation prior to placing a Chip Seal. Chip Seals can extend the life of pavements which are oxidized or aged, which causes the pavement to become brittle. It will also seal off surface cracks which are just beginning to form and restore the water proofing qualities needed in flexible pavements. Chip Seals also provide good skid resistance on pavements which have become polished or slick due to aging or bleeding. Chip Seals are often used to delineate main travel lanes where pavement is provided for errant vehicles, but not intended for continuous use. Where concrete or plant mix asphalts are used on primary routes, Chip Seals can be used on shoulders or gore areas to differentiate the riding surface from the shoulder or recovery areas.

One of the most interesting aspects of Chip Seals is the variability of the process. Chip Seals consist of one or more applications of emulsion and aggregate followed by rolling. Unlike plant mix pavements, Chip Seal design is greatly influenced by the old pavement it is being placed on. For example, a severely oxidized roadway will require a heavier asphalt rate on the initial pass whereas a roadway experiencing bleeding will require a slightly reduced asphalt rate.

The type of emulsion and aggregate can vary, and details of these variances will be discussed further in this manual. The type of Chip Seal (single, double or triple), and the size of the aggregate used in each pass will determine the overall depth of the seal. Chip Seal pavement depths rarely exceed an inch and are most often a quarter to a half-inch deep. The unique practice of varying emulsion and aggregate rates and types has generated the term the "Art of Chip Seals." This variability also makes quantifying a standard rate of application difficult. The rates given in Chapter 10 reflect this "art." Also, Chapter 5 will provide the standard specifications for Asphalt Surface Treatments.

This manual serves as one piece in this mission by providing a reference to 70 years of progressive experience in the "Art of Road Oil." The standard practices and everyday experiences of generations of Road Oil practitioners contained within this manual will help deliver a Chip Seal program which will propel North Carolina into the future, preserving it as the "Good Road State."