

### General

The roadway is the paved or otherwise improved portion of a public highway ordinarily used for vehicular travel. The roadway surface is normally classified as rigid (consisting of Portland Cement Concrete) or flexible (consisting of asphaltic materials).

A smooth surface with good skid resistance, free of alligator cracks, pumping, pushing, wheel rutting, raveling, frost heaving, and pot holing, is desirable for safe travel by the people we serve.

Maintenance of the state's roadways must include a program to preserve these characteristics. Ideally, the maintenance of pavement should be accomplished with minimum expense and with the least possible traffic disruption. Maintenance of pavements is a necessary investment made to protect the pavement from costly renovation or reconstruction.

Preventive maintenance is much more cost effective than performing major repairs. Area maintenance staff are required to inspect each section of highway at least once a year to detect and schedule deficiency repairs prior to their becoming a major problem.

A biennial appropriation corresponding with a specific, (LOS) Level of Service for roadway maintenance and operations activities is provided by the Washington State Legislature. The maintenance area's roadway surface program should be managed to meet these LOS commitments. In doing so, it is essential that each Area work with its Program Management, Design and Construction offices to ensure that the work being planned is coordinated with the work that these offices are planning and/or constructing.

It is advised that written recommendations for pavement repairs be submitted to the Regional Maintenance Engineer. The Regional Maintenance Engineer then shares the region wide roadway surface maintenance program with the Regional Construction Engineer. This allows better coordination between the maintenance and construction programs.

Pay special attention to the drainage of roadway sections when planning maintenance activities. Poor drainage can lead to premature aging of the roadway surface and sub-grade.

Work zone safety and traffic control are extremely important. Maintenance employees are required to know and closely follow the chapter in this manual on traffic control and safety.

## Maintenance of Flexible Pavements

Flexible pavements generally are referred to as asphaltic concrete pavement (ACP) or bituminous surface treatment (BST). Flexible pavements develop strength from the tight interlocking of crushed rocks with an asphalt material binding them together. This mixture deflects when loaded by traffic and exerts pressure on the subgrade. Consequently, both the pavement and the subgrade must be in good condition to avoid maintenance problems.

## Load and Speed Restrictions

If the subgrade temporarily lacks strength to carry heavy loads due to excess moisture and/or thawing, any class of vehicles can be restricted by weight and/or speed. Maintenance staff must monitor the roadway condition during threatening weather conditions. Take action according to Directive D 54-43 (MR), Emergency Restrictions for Roads, before the subgrade becomes saturated and soft. This will avoid unnecessary stress which can lead to permanent damage.

Restrictions should be no more severe or of longer duration than necessary to protect the roadway. Consider the economic effect to the users. The damage caused by failure to place restrictions on soft roadways can have a severe effect on a maintenance budget and their ability to meet LOS targets.

## Pavement Deficiencies

Damage and deterioration of pavements will become apparent in a variety of ways. A number of factors can contribute to the appearance of pavement deficiencies. For example, an overlay with excess asphalt or poorly graded or inadequately fractured paving material may not have adequate particle interlock; thus pushing, rutting, and humps may develop. Poor subgrade drainage, heavy tonnage, and accelerating or decelerating traffic are all potential sources of surface irregularities. Pavement deficiencies are explained in more detail as follows:

### ***Rutting***

Rutting is a surface depression within the wheel path and is a result of permanent deformation of the pavement or subgrade. This condition is normally caused by heavy loads on roads lacking sufficient strength to support the loading. In some cases, rutting can also be caused by studded tire use. Wheel ruts, if not repaired, can trap water and cause hydroplaning.

### **Alligator Cracking**

The condition known as alligator cracking is attained when discontinuous longitudinal cracks begin to interconnect to form a series of small polygons that resemble an alligator's skin. This distress is usually caused by poor drainage, poor mix design, or subgrade failure.

Ideally the surface should be treated with a seal coat or overlaid with suitable material before water has an opportunity to penetrate the surface and lead to alligator cracking. If it is neglected and alligator cracks appear, heavy traffic can push the surfacing rock into the wet soil beneath it. This forces mud up through the asphalt surface (pumping) causing permanent damage that can not be repaired by a seal or overlay. Spots where severe pumping has occurred will often need to be dug out, and the base rock, surfacing rock, and asphalt replaced.

### **Longitudinal Cracking**

A longitudinal crack follows a course approximately parallel to the centerline. These are typically resultant of natural causes or traffic loading.

### **Transverse Cracking**

Transverse cracks run roughly perpendicular to the roadway centerline. They may be due to surface shrinkage caused by low temperatures, hardening of the asphalt, or cracks in underlying pavement layers such as PCC slabs. They may extend partially or fully across the roadway.

### **Potholes**

Potholes are voids in the roadway surface where pieces of the pavement have become dislodged. Areas in which many potholes occur become suspect for fundamental problems such as inadequate drainage, pavement strength, or base/subgrade problems. Single or infrequent potholes may be the only pavement distress to occur in an area, and beyond the treatment of the individual pothole no other pavement repair work may be required.

The location of potholes which receive a temporary fix should be documented so they are addressed as part of the Area's annual permanent fix program. The number of potholes that appear in the wet or winter seasons is often an indicator of the effectiveness of the permanent fix program.

## ***Raveling and Pitting***

Raveling and pitting distresses are characterized by the loss or dislodgment of surface aggregate particles. Oxidized asphalt binder is often the cause of raveling and pitting. It could also be caused by poor compaction, letting the mix get cold when paving, dirty aggregate, not enough asphalt in the mix, overheating the mix during manufacture, or aging.

Routine maintenance repairs made to raveled or pitted surfaces is made as soon as conditions permit and/or materials are available. The most important consideration in scheduling repair of raveled or pitted areas is to perform the repairs before a more serious condition develops, and prior to the onset of inclement weather.

Open grade pavements that allow water to drain through and out the side don't need to be sealed if they are properly constructed. But, pavement that is raveling must be sealed. Unsealed pavements will continue to ravel and will also age and harden at a much faster rate than normal. This condition may also encourage the loss or stripping of the asphalt within the pavement. Timely sealing can add significantly to the life of the pavement. Open grade pavements should be fog sealed on a schedule recommended by the Region Materials Engineer. Failure to do so can lead to premature failure of the open grade mat and lead to difficult maintenance problems.

## ***Flushing***

Flushing (or bleeding) is free asphalt on the surface of the pavement caused by, too many fines in the mix, too few voids, too much asphalt in patches, or a chip seal that has lost its rock. This type of distress often shows as a shiny, glass-like reflective surface. It is inherent to unstable mixes and often results in other roadway surface distresses if not corrected.

Removal and replacement of flushed or bleeding pavement areas is an expensive, but sometimes cost-effective method of repair. Thin overlays of flushed or bleeding areas will frequently have the "fat spot" show through in hot weather and exhibit the same characteristics as in the "before" condition. If repairs are not possible prior to a seasonally wet period, contact the regional traffic engineer to evaluate the need for posting "Slippery When Wet" signs.

## ***Sags and Humps***

Sags and humps are localized depressions or elevated areas of the pavement that result from settlement, pavement shoving, displacement due to subgrade swelling, or displacement due to tree roots. The deficiency usually occurs in isolated areas of the roadway surface.

## ***Edge Raveling***

Edge raveling occurs when the pavement edge breaks and is most commonly found on those roadways that were constructed without curbs or paved shoulders.

## Pavement Maintenance Techniques

### Patching

All flexible pavements require patching at some time during their service life. Surface patching should be performed to a standard commensurate with resource availability and the objective of retaining a smooth ride as long as possible. Since patching materials are one of the larger material costs a high quality patch is one of the most cost effective means of utilizing available resources.

There are two principal methods of repairing asphalt pavements:

1. Remove and replace the defective pavement and surfacing or base material.
2. Cover the defective area with an overlay of a suitable material to renew the surface, seal the defective area, and stabilize the affected pavement.

These repairs can be called ‘dig-outs’ or ‘overlays’ according to the method used.

### Patching With Base Repair

“Dig-out patches” are used for making permanent repairs to the pavement. Defective pavement and unstable surfacing materials are removed down to a stable base. This may mean removal of some of the subgrade material. The excavated area should extend into the good pavement around the defective area by about 12 inches. Cut the edges of the patch area vertically and in straight lines to provide a good line for compaction later. A pavement saw makes a good tool for a fast, neat cut in pavement patching.

After the cut is made and the defective pavement and/or base material is removed, level and compact the base material. This will make an adequate foundation for the new asphalt concrete material. Surfacing materials (gravel base, crushed surfacing) and pavement must always be replaced in depths at least equal to the original design or by additional depth of ACP compacted in lifts of 1 to 3 inches. Apply a tack coat of asphalt to the vertical sides of the hole to assure a good bond and seal between old and new pavements.

For best results in a patch of this nature, back fill the hole with a hot plant-mix material such as Asphalt Concrete Class B. The asphalt should be compacted in lifts of no more than 3 inches thick to obtain optimum patch life. Small patch projects can be compacted with a vibrating plate compactor, while a roller works best on large patches. During hot weather it might be advantageous having some water on hand to help cool the mix between lifts. Standing water should not be allowed on the mix between lifts.

After the intermediate lifts of the patch have been compacted sufficiently, the surface lift can be completed. Take special care to ensure that it is compacted to be even and flush with the surrounding surface, so it provides a good riding surface. Some compaction will occur by traffic as the mix is further kneaded into place. The patch should be cool enough before traffic is allowed on it, so it will not leave marks in the surface. Deeper patches will require more time to cool and must be planned for accordingly.

Potholes and localized failures should be repaired as soon as possible after they are reported. Asphalt pre-mix (cold mix) should be available throughout the year so any potholes that appear can be patched immediately. Fiber reinforced, and other specialized ‘winter mix’ have been found to be effective in many locations. Many times the use of a propane torch to dry the holes and heat the mix for good compaction is time well spent.

The use of an asphalt ‘tack’ is highly recommended. A higher success rate is normally achieved when they are squared up and tack is added to the edge of the pothole. If the lack of availability or storage of standard tack is a problem, try using one of the cold pour crack pouring materials. They are available in (5) gallon buckets with a pour spout. Many pothole patching crews use this as standard procedure.

Do not use sand, clay, or other temporary patching material to patch or “pad” potholes or frost boils. On today’s roads these methods usually cost more in the long run and often leave unsafe conditions for the traveling public. Asphalt pre-mix is the preferred method, even if it has to be replaced when final repairs are made.

For permanent pothole patching proceed as follows:

- Remove the defective material down to a stable base.
- Square off the edge of the hole vertically.
- Dry the hole as much as possible (fiber reinforced mix often does well in wet holes).
- Tack the hole if possible.
- Place and compact the mix.

Compaction is very important in making the repair permanent (heat applied to the mix is very beneficial to good compaction). If traffic is picking the fresh mix out of the hole try dusting the finished patch with some roadside dirt. Spend a little more time patching the pothole the first time. This will often keep you from returning to patch the same hole repeatedly. Permanent repairs are normally made with hot mix if available.

### **Overlay Patches**

Overlay patches are generally applied when an area is too large to be economically repaired by hand with a small crew. The overlay patch, with hot plant-mix asphalt, also has the advantage of setting quickly. It does, however, commit a considerable investment in labor, equipment, and materials.

Typically, overlay patches are applied in areas of pavement failure or wear problems rather than areas with a base or subgrade problem. Ruts, raveling, pitting, minor cracking, and oxidation are typical failures where overlay can be effective in quickly and permanently restoring the surface. When addressing pavement rutting, mix should be placed in lifts when patching rutted areas in order to get uniform compaction. This method of compaction will help prevent the rut from reflecting into the finished patch. To obtain proper compaction in the wheel ruts, a rubber tired roller should be used. Steel wheel rollers will bridge the rut and very little compaction will occur. After the ruts are filled and if it is decided to overlay the entire lane then a steel wheel roller would be used for compaction.

Application of any overlay patch requires a considerable degree of skill, coordination, and planning. All loose, broken asphalt should be removed and replaced. Any deep ruts, depressions, or humps should be repaired or pre-leveled in advance of the overlay so that the overlay may proceed efficiently. It is necessary to repair these areas prior to the overlay in order to provide an even platform for the new pavement. This is essential to proper compaction and consequently to pavement life. If, for instance, wheel path ruts are overlaid without pre leveling, the ruts will not get the same compaction from rolling that the thinner high spots will. Then traffic wheel loads will eventually compact the deeper new sections, causing ruts to reappear. All areas should be tacked before patching to ensure a good bond and minimize raveling in thin areas. The tack rate should be 0.4 to 1.4 gallon per square yard of applied tack (0.2 to 0.8 residual).

Be careful when repairing the roadway surface in an area of unpaved shoulders. Widening over thin gravel or dirt shoulders will usually lead to cracking and failure. This is because of the lack of sufficient top course material. If there is the need to widen the paved roadway, make sure the shoulder is prepared properly to support the anticipated loading.

### **Spreader Box Patching**

On small paving jobs it is often convenient and economical to use a tow-behind paver, or spreader box. These pavers hook to the rear of the trucks that are hauling the mix. The asphalt is dumped directly in the hopper of the paver which places it on the roadway or base material.

As the towing vehicle moves ahead, the mix is struck off by an adjustable height blade (cutter bar or screed) and is surface-finished by the screed. Starting the paving at full depth requires setting the screed on blocks before filling the hopper. The hopper should be kept uniformly full during paving to ensure an even spread. An even towing speed is necessary to maintain a uniform spread thickness.

Spreader boxes vary greatly in size, operating controls, accessories, and capabilities. Working with them requires skill and experience. Manufacturers and construction equipment dealers can provide assistance in the operation and care of particular models.

Clean-up of equipment and tools after each day's operation is essential to good patches. This is especially true of the spreader box. It must be kept free from the accumulation of cold asphalt. Diesel is generally the most common and effective release agent used for cleaning tools and equipment. However, the diesel-asphalt waste mixture must be captured (i.e. not allowed to spill on the ground) and placed into (55) gallon containers for disposal as a "Dangerous Waste". A "Dangerous Waste" label should be placed on the waste container and the date entered as to when the accumulation began.

Spreader box patching with hot plant-mix material has the advantage of providing a smooth finished surface, when the equipment is properly operated. Several people are required to operate a spreader box efficiently. Careful planning of the patching operation is very important to economical and cost-effective pavement maintenance. The spreader boxes can work well if surface irregularities are pre-leveled with equipment appropriate for the conditions. The entire surface should be tacked, both before pre leveling and before starting the spreader box patch.

Rolling of the hot plant-mix should begin immediately after placement of the mix. If the mix is allowed to cool below 185 degrees before rolling, adequate compaction will not be possible.

### **Grader Patching**

Road graders are a useful pavement patching tool. These graders vary in size, model, and capabilities depending on their intended use.

One efficient way of blade patching is using two graders facing each other. This method is quicker than the single blade method, and can help in getting the patch laid before the mix gets cold. It helps keep coarse mix away from the ends of the patches, making smoother approaches, and helps keep a straighter edge. Also, a two grader operation offers a good opportunity to train inexperienced grader operators.

Hot plant-mix patching with graders is frequently accomplished when it is not practical or economical to use other means. Gradgers are especially valuable for leveling to eliminate sharp depressions or sags and to lay a leveling course of pavement prior to placing finish courses with asphalt spreader boxes. They are excellent to place a leveling course to restore the roadway grade and shape when it cannot be done with a paver or spreader box. All of the area to be blade patched should be tacked. Road graders with a long wheel base and smooth-tread tires are often used for spreading hot plant-mix asphalt in leveling operations. The roller must follow the grader immediately after the mix is spread while it is still hot.

Graders are not efficient at carrying large quantities of material over long distances, so the dumping of asphalt should be carefully controlled for an efficient operation. A dump person should be utilized. Make as few passes as possible with the grader to reduce segregation of the material.

### **Rolling Hot Mix Patches**

It is always desirable to use the most effective tools for the job at hand, including asphalt work. The use of a finish lute person on the patching crew is highly desirable. The quality and ride of the patch is often much better due to their expertise. If short handed, consider borrowing people from an adjacent section so you can provide a quality product. Since patching is one of the most expensive operations to perform, it is essential to develop work schedules that ensure the following are present: desirable weather conditions, adequate staffing, and proper equipment.

A 10 ton or larger steel-wheeled roller is valuable to an efficient asphalt patching operation. A lighter vibratory roller is a poor substitute, as it can slow the operation considerably. On larger paving projects, one roller may be used to do the breakdown rolling or initial compaction, with another used for the finish rolling.

The patching operation should match the speed of the roller. If the patching crew outpaces the roller, it forces the rolling of mix that is too cold and a poorer quality patch can result. If the operation needs to move faster and the roller can't keep up, use a larger roller or a second roller. Do not compact hot mix asphalt concrete at a temperature below 185 degrees F. Rolling mix that is too cold can cause it to crack. Rolling mix that is too hot can cause pushing. The maximum temperature of mix from the plant is 350 degrees.



Compaction is among the most important phases of the operation. All asphalt concrete patches, small or large, must be compacted to consolidate the material. The properly compacted asphalt patch will be tough and dense and will stand up to the wear of traffic and weather much better than if compaction is inadequate. However you compact the mix, do it well; it is very important.

Rolling for compaction should begin as soon as the paving material is laid. The initial rolling or “breakdown” gives the highest percentage of compaction of any rolling phase. Consequently, it also offers the most potential for material displacement at the edges. It is important to make the initial breakdown pass at least 4 inches away from the edges of the mat. A subsequent pass will level this edge.

Avoid stopping the roller or reversing direction on the hot mat. Do not turn on the mat while moving. This can affect the ride of the patch.

Intermediate rolling further compacts and seals the surface. Finish rolling removes any roller marks and other blemishes left by prior rolling.

Various roller types are used in asphalt compaction. Steel-wheeled, vibratory, and pneumatic tired are the types most commonly available. Steel wheeled and vibratory rollers are used for all three phases of asphalt rolling. Vibratory rollers should not be operated on thin lifts and so are not generally used in maintenance patching operations. Rubber-tired rollers are not normally used in maintenance operations.

All rollers used in asphalt paving or patching operations should be:

- In good operating condition.
- Used according to the manufacturer’s recommendations.
- Capable of reversing direction without backlash.
- Able to operate at speeds low enough to avoid displacement of the hot asphalt.

Do not use rollers producing pickup, washboard, uneven compaction, or otherwise undesirable effects. Vibratory rollers under vibration should not exceed (3) mph. Steel-wheeled rollers should be limited to (4) mph and pneumatic tired rollers to (5) mph maximum. The drive wheel of the roller should always be pulling the roller to prevent displacement and pushing of the material. This is particularly important on steeper grades and in breakdown rolling passes.

## Effects of Traffic on a Patching Operation

Timing is critical while doing hot asphalt mix patching. Cold asphalt mix yields inferior patches. Flaggers must avoid delaying asphalt trucks and paving equipment while hot mix patching. Don’t let traffic drive on any unrolled mix. A finished patch should be cool enough to hold your hand on before traffic is allowed to drive normal speeds on it. A pilot car offers a big advantage for multiple patches over an extended section of roadway. The use of a third flagger to keep traffic off the unfinished mix and away from the equipment is desirable. Traffic striping that is blacked out or covered should be remarked the same day for safety reasons.

## Crack Sealing (or Pouring)

There are significant costs involved in filling cracks, both for materials and labor, the supervisor needs to be aware of the nature, extent, and severity of the cracking problem and also of the next scheduled contract for resurfacing. Filling cracks in an area scheduled for immediate reconstruction or resurfacing by contract is not recommended unless it is a part of the overall project. Minor repair and crack sealing is often part of the contractor's responsibility. However, sealing minor cracking may extend the useful pavement life for several years when an overlay project is not scheduled.

Generally, alligatoring or more general cracking can be repaired most cheaply by chip seals. Serious cracking and settlement of the pavement may indicate the need for excavation to repair the subgrade before patching can be successful.

The main purpose of crack pouring is to prevent water from entering the subgrade and causing damage. There are two widely used types of crack pouring material in highway maintenance, hot pour and cold pour. The two types use different techniques and equipment. The purpose of the two is the same, to minimize water entry and resulting damage.

Over-poured cracks can be a safety hazard to motorcycles. Overband (over-poured) crack pouring, especially on longitudinal cracks, can cause loss of control for motorcycles. The problem is compounded on curves or when the surface is wet. Cracks that are not over filled do not seem to cause a problem. Areas that have excessive crack pouring material from past practices should be addressed.

### **Hot Pour Method**

This method utilizes blocks of crack pour material heated in specialized crack pouring machines. The most common type in maintenance are trailer mounted, oil jacketed units. This method is often used by contractors and maintenance crack sealing distressed areas that are not going to be removed and repaired prior to an overlay. It is a common method of sealing the joint between the edge of a PCC road surface and the asphalt shoulder. It works well for large volume work involving large cracks. Often the cracks are routed out first. If not, they should be cleaned and dried with compressed air prior to pouring. Filling cracks with this method requires a large crew and specialized equipment.

Safety is a big concern in a hot crack pour operation. This material is extremely hot and can cause severe burns when loading the machine or applying the material.

### **Cold Pour Method**

This method utilizes cold applied liquid material and does not require specialized equipment. This type of material is available in 5- to 50-gallon containers. It can be sanded lightly after application and opened to traffic. One person can apply it using the spout on the 5-gallon bucket it comes in.

Experience has shown that for maintenance purposes cold pour seems to prevent water entry into the subgrade as well as hot pour material. It also resists build up on bumps better than the hot material does.

Cold pour is excellent as tack for small asphalt patches and pothole repairs. It greatly simplifies the problems of tack storage, transporting, and application. A sealed five gallon bucket can be carried easily by a pothole patching crew.

This material works well for hand pouring the cracks around an isolated bridge drain or catch basin if a piece of foam ‘backer rod’ is poked down into the crack before pouring to serve as a bottom for the material. It can also be poured against rubber expansion joints without melting the rubber joint.

## Maintenance of Rigid Pavements

Rigid pavements are generally referred to as Portland Cement Concrete Pavement (PCC). PCC pavements should be patched with Portland Cement Concrete or one of the WSDOT approved patching materials. Prepare and apply patching materials according to the manufacturer instructions. If recommended by the patching material manufacturer, use a bonding agent.

The PCC surface to be repaired should have all loose material removed down to solid material or to full depth if necessary. A jackhammer or similar equipment may be necessary to remove some of the material in the area to be patched. The area to be repaired needs to be squared by concrete sawing, then sand blasted, cleaned and dried.

Delamination occurs when a thin layer of surface concrete has lost bond with the underlying concrete. The area around the patch should be checked for delamination. Tapping on the surface with a hammer and listening for a hollow sound is one way to find the delaminated areas.

If reinforcing steel is encountered, remove or neutralize all rust. Coat exposed reinforcing steel with a WSDOT approved product to prevent rust from reoccurring. Then proceed with patching the area.

Traffic should be kept off the new patch as specified by the manufacturer, until it gains sufficient strength to support traffic.

## Portland Cement Concrete Pavement Crack Pouring

Joints in Portland Cement Concrete Pavements (PCC) compensate for thermal movements of the pavement and provide load transfers between slabs. Properly sealed joints in concrete pavements prevent water from entering into and weakening the underlying base and subgrade materials. Properly sealed joints also prevent incompressible materials such as dirt and gravel from penetrating into joints, which then restricts thermal joint movements. Materials that restrict the natural expansion of the pavement joints can cause diagonal slab cracking, slab blowups, or tipping and spalling.

PCC joints and cracks should be checked before the wet season to make sure they are sealed to prevent entry of damaging water.

Even fine cracks in steel reinforced slabs can be serious. They can allow water or chlorides to reach the steel causing corrosion and serious damage.

PCC crack pouring is most effective when the pavement is cold and has contracted and opened the cracks. Don't pour cracks when the pavement temperature is below 45 degrees. Always use WSDOT approved crack sealant material.

Cracks must be routed out before pouring. If not, they should be cleaned and dried with compressed air prior to pouring. Foam backer rod can be used in larger cracks to keep the sealant in the top 1 inch of the crack.

Safety is a big concern in a hot pour operation. This material is extremely hot and can cause severe burns when loading the machine or applying the material.

Asphalt Concrete Paving Quantities (Tons/100 lin ft)						
Width (ft)	Depth of Mix (Compacted)					
	1"	2"	3"	4"	5"	6"
2	1.2	2.4	3.6	4.8	6.0	7.6
4	2.5	5.0	7.5	10.0	15.0	15.2
6	3.8	7.6	11.4	15.2	19.0	22.8
8	5.0	10.1	15.0	20.0	25.0	30.4
10	6.3	12.6	18.9	25.2	31.5	38.0
11	7.0	14.0	21.0	28.0	35.0	42.0
12	7.6	15.2	22.8	30.4	38.0	45.6
16	10.1	20.2	30.4	40.6	50.7	60.8
18	11.4	22.8	34.2	45.6	57.0	68.4
20	12.4	25.2	37.2	49.6	62.0	76.0
22	14.0	28.0	41.8	56.0	70.0	83.7
24	15.2	30.4	45.7	60.8	76.0	91.3

Mix Quantities in Patches		
Mix Class	Size	
Class A	5/8"-0"	Higher grade mix, more fractured rock, has good strength
Class B	5/8"-0"	Standard mix in many areas
Class D	3/8"-0"	Open grade mix, used in thin overlays, can ravel bad as it ages
Class E	1 1/4"-0"	Coarse mix
Class F	5/8"-0"	Lower grade mix, less fracture, more round rock, contains more fines & has less strength
Class G	3/8"-0"	Fine mix, good for wheel ruts & skin patches
Asphalt Treated Base Mix	2"-0"	Specs allow down to 1/2" maximum size rock

## Classes of Asphalt Concrete Pavement (ACP)

Sources for Additional Pavement Maintenance Information

### Asphalt Institute Publications

- MS-4 *The Asphalt Handbook*
- MS-5 *Introduction to Asphalt*
- MS-8 *Asphalt Paving Manual*
- MS-14 *Asphalt cold-Mix Manual*
- MS-15 *Drainage of Asphalt Pavement Structures*
- MS-16 *Asphalt in Pavement Maintenance*
- MS-17 *Asphalt Overlays for Highway and Street Rehabilitation*
- MS-19 *Basic Asphalt Emulsion Manual*

### WSDOT Publications

- Standard Specifications for Road, Bridge, and Municipal Construction* M 41-10
- Construction Manual* M 41-01
- Design Manual* M 22-01

## Asphalt Emulsion Surface Treatment

Preventive maintenance programs started early in life of a pavement (1-3 years) provide the protection needed to greatly improve service life. For aged pavements, surface treatments can delay the costs of major reconstruction. Asphalt emulsion surface treatments are excellent for preventing the development of early pavement damage or distress. The surface treatment seals the pavement, retards the aging process and prevents the old pavement from further hardening. One method of sealing minor cracks and providing a renewed roadway surface is called Bituminous Surface Treatment (BST). BST is used to seal small cracks, repair a dry raveling surface and provide a skid resistant surface.

### Fog Seals

In instances of a pavement with very minor raveling, a fog seal may adequately seal the pavement and prevent further raveling. Fog Seals are very light applications of diluted, quick breaking asphalt emulsions. Some of the asphalt materials used for fog seals are: CSS-1 and STE-1 which are cationic (positively charged) emulsions, while HFE-100S-50% diluted is an Anionic (negatively charged) emulsion. These products may require cover material ( $\frac{1}{4}$  - 0) depending on the surface and application rate. The decision whether to use a cationic or anionic formulation should be based on knowledge of the charge of the existing materials used as part of the pavement. Understand that like charged materials repel each other and opposites attract. We want the materials to attract each other and make a tight bond. The Region or the Headquarters Materials Lab can assist in the determination.

Asphalt emulsions used for fog seals are usually diluted 50 percent with water or other types of cut-backs as prescribed by the manufacturer. The Fog Seals are applied at the rate of 0.1 to 0.2 gallons (of diluted material) per square yard, depending on the texture and porosity of the old pavement. The application rate will be determined by the amount of emulsion the old pavement surface can absorb without becoming slippery. Traffic control may be required for up to two hours, depending on location and volume of traffic.

### Sand Seal

Where more raveling has occurred, a sand seal may be needed to adequately seal the surface and provide a quality surface. A sand seal is an application of liquid or emulsified asphalt covered with fine aggregate. It is used to seal against air and water infiltration, or improve skid resistance. Applications are 0.1 to 0.2 gallons of CRS-2 or CMS-2 per square yard covered with ten pounds of  $\frac{3}{8}$  minus aggregate. Some regions have found  $\frac{1}{4}$  minus to be better suited for sand seals.

### Aggregate (Chip) Seal

If the raveling becomes more advanced, an aggregate or chip seal may be needed. In cases where raveling is allowed to progress to the point where the ride is affected, a thin overlay, or pre-leveling followed by a chip seal, might be needed. An aggregate seal is a single spray application, usually of a liquid or emulsified asphalt. Immediately following is a single layer of aggregate of as uniform a gradation (size) as practicable. This type of seal reduces the infiltration of air and water into the mat and may be used to improve skid resistance of slippery pavements.

Chip seals are useful and can be applied in many different ways: Full lane width, partial lane width, short longitudinal sections or for long sections.

A typical example of a BST uses application rates for CRS-2 or HFE-100S at .40 to .60 gallons/per square yard with 30 to 40 pounds of  $\frac{3}{8}$  -  $\frac{1}{4}$  Crushed Cover Stone per square yard. Look in the *Standard Specifications* Sections 5-02, 9-02, and 9-03.4 for additional information on Bituminous Surface Treatment and materials.

## Pavement Conditions for a Successful Project

Prior to sealing thoroughly, examine the roadway surface. Then decide what kind of repair is needed. A chip seal does not add to the structural integrity of pavement. Therefore, the existing pavement must be structurally sound in order to obtain a long performance life. Existing pavements may have to be repaired; patched, crack sealed and then allowed to cure before a chip seal can be applied. Always clean the existing roadway surface before starting the chip seal process.

Since chip seals follow the original profile of the pavement, they do not correct surface irregularities. Chip seals cannot be used on pavements with more than  $\frac{3}{8}$ " to  $\frac{1}{16}$ " of rutting. Aggregates in the ruts can not be fully compacted. Cleaning loose aggregate from the rut with a power broom will dislodge the aggregate from the non-rutted area. If the surface has light-to-moderate bleeding, the binder application rate should be reduced. Don't use a chip seal on pavements with a high severity of bleeding.

## Material Selection

### *Asphalts and Emulsions*

The two general types of asphalt for seal coating are liquid asphalt and emulsified asphalt. Liquid asphalts are graded by viscosity. SC-Slow Cure-70, MC-Medium Cure-70, RC-Rapid Cure-70, have the lowest viscosity. SC, MC, RC 3000 have the highest viscosity. Liquid asphalts are also graded by the type of solvent used to thin them: SC with light oil, MC with kerosene, and RC with naphtha cutback. MC 3000, RC 3000, or RC 800 are the liquid asphalts used for chip sealing. Emulsified asphalts are manufactured by suspending asphalt particles in water with the aid of an emulsifying agent. Asphalts for Bituminous Surface Treatment are listed in the *Standard Specification* Section 9-02.

### *Common Types of Emulsions Used for Chip Seals*

CRS-2 (Cationic Rapid Set Emulsion) is one of the most widely used emulsions. This emulsion will run into wheel ruts and down super elevated roadways if applied at rates above 0.4 gallons per square yard. CRS-2 provides a good seal on low volume highways.

HFRSP2/HFE-100S (Anionic Styrelf Polymer High Float Emulsion) is used for chip seals. It is a rapid setting emulsion that binds the chips very fast and can be used on high volume roads. This product should not bleed under high pavement temperatures.

## **Aggregate**

Aggregate for bituminous surface treatment must conform to the requirements in the *Standard Specifications* Section 9-03.4 for grading and quality. The material must meet the requirements for grading and quality when placed in hauling vehicles for delivery to the roadway. During manufacture and placement into a temporary stockpile the exact point of acceptance will be determined by the Engineer or Area Superintendent. The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other contaminants. Crushed screenings must be substantially free from adherent coatings.

## **Weather**

The best time of year for a seal coat is when the weather is hot and dry during, and for some weeks after, treatment. Specifications require the air temperature in the shade to be at least 60 degrees Fahrenheit before work begins. No matter what the temperature of the asphalt when sprayed, it will cool to the temperature of the pavement surface in one minute. BST treatments should be placed between May 15th and August 15th for best results.

Never start a BST when the surface is wet or when it is threatening to rain. If the fresh seal gets wet, the combination of water, fresh seal coat, and traffic will result in loss of the cover aggregate.

## **Roadway Preparation**

The surface should be thoroughly cleaned of all loose materials prior to application of asphalt. Sweep the roadway surface before starting the job. This allows the dust to be either flushed with water or blown off the roadway surface by traffic.

If patching is needed, allow time for the patch material to cure prior to sealing. Generally, two weeks should be allowed for hot mix to cure. Allow six weeks at temperatures of 50 degrees to 60 degrees Fahrenheit for cold mix to cure. To preserve the centerline location place flexible reflective markers prior to the seal. These can also be used to indicate the beginning and end of no passing zones. Flexible reflective markers have a removable cover so that they retain their reflectivity after the seal. They will also function as guidance for the striper truck.

## **Equipment**

Before any work begins, examine all equipment to ensure it is in good working condition. Check spreader boxes or aggregate spreaders to see they are in proper working order. The roller operator should make sure that each tire on the roller is equally inflated to correct pressure and that controls for steering, starting, and stopping operate smoothly. All tires should be the same size and the water spray and scraper system must be checked to ensure material does not bond to the tires.



## Distributor

New distributors use a ground speed control sensor and computer to regulate material application rates. Set the computer to the desired rate and the application will be correct even if the vehicle speed varies.

Older distributors are equipped with hydrostatic drive systems. The hydrostatic drive consists of a variable output pump driven by the truck power take off (P.T.O.). This in turn drives the distributor asphalt pump with a hydrostatic motor. Once the correct ratio between ground speed and pump flow rate is established for a given transmission setting, the truck ground speed may be varied without affecting the application rate. The operator needs a dry run to establish correct ratio between pump flow rate and ground speed.

Determine from the road computer (Slide Rule) the correct ground speed (F.P.M.) and pump flow rate (G.P.M.) for the desired spray bar length (FT.) and application rate (GAL/SQ. YD.). Follow the correct operation procedures set up in your distributor manual for calibration.

## Calibration Procedures

### Distributor Calibrations

**Step 1** – Calculate how much material is in the holding tank. The following methods work to calibrate an older distributor and calculate the application rate.

- **Method 1** – Determine the number of gallons in the distributor. This can be done by several methods. The first and most accurate is to weigh the distributor before loading and after loading. Subtract the weights and divide by the pounds per gallon the emulsion weighs. This equals the total gallons.
- **Method 2** – Find a level spot (the distributor tank must be level). Use a dip stick to dip the tank. Measure the number of inches covered with asphalt. After you know the size of the tank, you can calculate the number of gallons in the tank.
- **Method 3** – Use the meter on the distributor tank. This is a good method for checking the above calculations but is **not recommended** for calibrating purposes.

Methods 1 and 2 are recommended for Measuring Distributor Tank (MDT) equipment prior to the start of the project.

**Step 2** – Apply asphalt to a known distance (minimum 200 feet) and established width.

**Step 3** – Determine the total square yards covered with emulsion. This can be done by doing the following calculation:

$$\frac{\text{Length Traveled (feet)} \times \text{Width Covered (feet)}}{9} = \text{Square Yards}$$

**Step 4** – Determine the number of gallons remaining on the distributor. Again use Method 1 or Method 2 explained in Step 1.

**Step 5** – Subtract the total gallons on the distributor originally from the total gallons left on after applying asphalt. This will give the gallons used.

**Step 6** – Divide the total gallons used by the total square yards covered:

$$\frac{\text{Total Gallons}}{\text{Total Sq. Yd}} = \text{Gallons/Sq. Yd.}$$

**Step 7** – To check your application rate on the project, follow the same steps except use Method 3 outlined in Step 1 to determine the number of gallons on the distributor.

### **Nozzle Size**

The spray bar and nozzles are an important part of the distributor. The proper quantity of asphalt must be spread uniformly on the road surface through the spray nozzles. To achieve good results, correctly sized nozzles must be selected for the job conditions. For example: if nozzles are too large for the desired application, pulsation of the spray may occur, resulting in uneven longitudinal spreading of the asphalt.

Each equipment manufacturer has specific recommendations for the size of spray nozzles to be used for different applications. Use the manufacturer's recommendation when choosing the correct nozzle size. All nozzles selected for use at any one time should have the same size opening.

### **Proper Pressure**

The spray bar must have a constant, uniform pressure along its entire length for equal output from all nozzles. Be sure the spray bar and nozzles are CLEAN.

Although several methods are used to maintain pressure, distributors use gear-type pumps to deliver asphalt to the spray bar. Pressure is governed by variable pump speed on some distributors and by constant pump speed and a pressure relief valve on others. Each application should be checked, as recommended by the manufacturer.

The correct pump speed or pressure are critical to the proper application of the asphalt. Too low a pressure will result in a non-uniform discharge/streaking of material from the individual nozzles. Too high a pressure, in addition to atomizing the asphalt, will distort the spray fan.

When a metering system is used, the manufacturer supplies the distributor with charts for finding the proper pump speed for each application rate.

When a pressure relief valve is used, the pump runs at a constant speed and the pressure is automatically held in the spray bar. The manufacturer supplies charts for determining the discharge in gallons per minute for each size nozzle, the proper truck speeds for various application rates, and the corrections for temperature-viscosity variations.

Gals. per Sq. Yd.	Width (feet)														
	1	2	6	7	8	9	10	11	12	14	16	18	20	24	24
0.10	1.1	2.2	6.7	7.8	8.9	10.0	11.1	12.2	13.3	15.6	17.8	20.0	22.2	24.4	26.7
0.15	1.7	3.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	23.3	26.7	30.0	33.3	36.7	40.0
0.20	2.2	4.4	13.3	15.6	17.8	20.0	22.2	24.4	26.7	31.1	35.6	40.0	44.4	48.9	53.3
0.25	2.8	5.6	16.7	19.4	22.2	25.0	27.8	30.6	33.3	38.9	44.4	50.0	55.6	61.1	66.7
0.30	3.3	6.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	46.7	53.3	60.0	66.7	73.3	80.0
0.35	3.9	7.8	23.3	27.2	31.1	35.0	38.9	42.8	46.7	54.4	62.2	70.0	77.8	85.5	93.3
0.40	4.4	8.9	26.7	31.1	35.6	40.0	44.4	48.9	53.3	62.2	71.1	80.0	88.9	97.8	107.
0.45	5.0	10.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	70.0	80.0	90.0	100.	110.	120.
0.50	5.6	11.1	33.0	38.9	44.4	50.0	55.5	61.1	66.7	77.8	88.9	100.	111.	122.	133.
0.55	6.1	12.2	36.7	42.8	48.9	55.0	61.1	67.2	73.3	85.5	97.8	110.	122.	134.	147.
0.60	6.7	13.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	93.3	107.	120.	133.	147.	160.
0.65	7.2	14.4	43.3	50.6	57.8	65.0	72.2	79.4	86.7	101.	115.	130.	144.	159.	173.
0.70	7.8	15.6	46.7	54.4	62.2	70.0	77.8	85.5	93.3	109.	124.	140.	156.	171.	187.
0.75	8.3	16.7	50.0	58.3	66.7	75.0	83.3	91.7	100.	117.	133.	150.	167.	183.	200.
0.80	8.9	17.8	53.3	62.2	71.1	80.0	88.9	97.8	107.	124.	142.	160.	178.	196.	213.
0.85	9.4	18.9	56.7	66.1	75.5	85.0	94.4	104.	113.	132.	151.	170.	189.	208.	227.
0.90	10.0	20.0	60.0	70.0	80.0	90.0	100.	110.	120.	140.	160.	180.	200.	220.	240.
0.95	10.6	21.1	63.3	73.9	84.4	95.0	106.	116.	127.	148.	169.	190.	211.	232.	253.
1.00	11.1	22.2	66.7	77.8	88.9	100.	111.	122.	133.	156.	178.	200.	222.	244.	267.
1.10	12.2	24.4	73.3	85.5	97.8	110.	122.	134.	147.	171.	196.	220.	244.	269.	293.
1.20	13.3	26.7	80.0	93.3	107.	120.	133.	147.	160.	187.	213.	240.	267.	293.	320.
1.25	13.9	27.8	83.3	97.2	111.	125.	139.	153.	167.	198.	222.	250.	278.	306.	333.
1.30	14.4	28.9	86.7	101.	116.	130.	144.	159.	173.	202.	230.	260.	288.	318.	347.
1.40	15.6	31.1	93.3	109.	124.	140.	156.	171.	187.	218.	249.	280.	311.	342.	373.
1.50	16.7	33.3	100.	117.	133.	150.	164.	183.	200.	233.	267.	300.	333.	367.	400.
1.75	19.4	38.9	117.	136.	156.	175.	194.	214.	233.	272.	311.	350.	389.	427.	467.
2.00	22.2	44.4	133.	156.	178.	200.	222.	244.	267.	311.	356.	400.	444.	489.	533.
2.25	25.0	50.0	150.	175.	200.	225.	250.	275.	300.	350.	400.	450.	500.	550.	600.
2.50	27.8	55.6	167.	194.	222.	250.	278.	306.	333.	389.	444.	500.	556.	611.	667.
2.75	30.6	61.1	183.	214.	244.	275.	305.	336.	367.	428.	489.	550.	611.	672.	733.
3.00	33.3	66.7	200.	233.	267.	300.	333.	367.	400.	467.	533.	600.	667.	733.	800.

**Note:**

Formula used for calculation:

$$Q = \frac{100W}{9} \quad R = 11.11WR$$

Where:

Q = Quantity of asphalt required, in gallons per 100 ft (l/m)

R = Rate of application in gallons per sq. yd. (l/m<sup>2</sup>)

W = Width of application, in feet (m)

For metric conversion factors see pages 6-A and 6-B Metric formula for calculation:  
Q = LWR where L = length in metres.

**Gallons of Emulsified Asphalt Required Per 100 linear Feet: Various Widths and Rates**

## Spray Bar Height

The height of the spray bar above the pavement surface is probably the most important adjustment to assure uniformity of asphalt spread. Correct height must be maintained during the entire application. If the spray bar is too low or too high, streaking will result.

The preset height above the pavement surface should not vary more than ½ inch. The bar will not stay within this tolerance, however, unless the manufacturer or the contractor takes steps to ensure that it does. As the asphalt leaves the spray bar, the load lightens and the springs raise the distributor. If there is an appreciable amount of deflection in the springs, the spray bar can rise as much as 4 inches, resulting in an uneven application.

Excess vertical movement of the spray bar can be corrected in several ways. After the bar height is adjusted with a full load in the tank, the frame of the distributor can be tied down to the axle during the spreading runs. If it is a truck-mounted distributor and has an adjustable type spray bar, mechanical controls can be supplied by the manufacturer to maintain the proper height, regardless of the deflection in the springs. On trailer-mounted distributors, bar height control is not necessary because of the small deflection of trailer springs. In any event, the height of the bar should be checked after each run and any necessary adjustment made at that time.

**Triple Coverage** – This is where any point on the roadway surface will receive overlapping spray from the two adjoining nozzles.

- **4-Inch Nozzle** – Best results with 4-inch nozzle spacing will come from an exact triple coverage of the spray fans. A simple test procedure assures the proper height setting of a spray bar with 4-inch nozzle spacing. One can determine by visual inspection whether or not an exact single coverage of asphalt is being applied. To begin, the second and third, fifth and sixth, eighth and ninth, etc., nozzles are closed, using the center section of the bar only. The distributor is then operated at the correct pump speed/pressure with the spray bar height changed not more than ½-inch at a time until the proper height is obtained. When an even single coverage of asphalt, heated to the proper spraying viscosity, is applied to the surface, it will give a uniform triple coverage with all nozzles operating.
- **6-inch Nozzle** – The height of bar necessary to give a triple coverage will frequently cause wind distortion of the spray fans, resulting in non-uniform application. A double coverage is therefore recommended for 6-inch nozzle spacing.

**Double Coverage** – This involves the same procedure as above except that every other nozzle is left open; the remaining ones are shut off. If the distributor has already been checked for double coverage, increasing the spray bar height by 50 percent will give triple coverage.

### **Proper Nozzle Angle**

Adjust nozzle opening angles so the spray fans will not interfere with each other. The nozzle angle will vary according to the make of the distributor. The angle recommended by the Asphalt Institute, measured from the spray bar axis, is 15 to 30 degrees.

Manufacturers furnish special wrenches for setting the angle of the nozzles. The use of these wrenches is recommended, as it is extremely difficult to obtain a uniform spread with visually set nozzles. All nozzles should be set at the same angle except for the cut-off nozzle. (end nozzle) Manufacturers make a nozzle with ½ spray pattern for this purpose.

At the time the angle of the nozzles is set, the edges of the nozzle openings should be inspected to see that they are not damaged. A nicked or otherwise damaged edge will produce a distorted fan of asphalt.

### **Streaking Will Occur**

- If the asphalt is too cold.
- When the viscosity of the asphalt is too high.
- If the snivies are not at the same angle.
- When the bar is too high.
- When the bar is too low.
- When the bar pressure is too high it cuts furrows because the snivies are too small and/or there is too much pump pressure.
- When the bar varies in height from a full to an empty distributor, blocking or locking against the overload springs will reduce or eliminate this variance in height.
- When the bar is too long and/or the snivy openings are too large for the pump capacity, this results in narrow and fluttering fans. Smaller snivies and/or higher pump capacity will correct this.
- If the pump pressure is too low it will create narrower spray fans and fluttering.
- If the distributor tank is allowed to run completely empty, an irregular pattern of misses and fluttering will occur across the bar. For this reason, the shot should be terminated while approximately 100 gallons are left in the distributor.

### **Cleaning of Distributor**

Cleaning of the distributor should take place in an area determined by its characteristics that are protective of the environment. For example: areas near waterways or with high seasonal water tables would not be necessarily suitable. These cleaning areas may require all fluids to flow through an oil water separator and all tank and bar cleaning agents to be barreled and labeled for disposal. No discharging or blowing your distributor bars in the ditch line, upon the right of ways or on private property is allowed, this could result in a serious violation.

## Checking the Bitumeter

A bitumeter consists of a rubber-tired wheel, mounted on a retractable frame, with a cable leading to a circular dial in the cab of the vehicle. The dial registers the rate of travel in feet per minute and the total distance of each trip in feet. At least one manufacturer furnishes a dial that registers the application rate in gallons per square yard in addition to travel in feet per minute.

Check the bitumeter at regular intervals to ensure accurate registering of speeds when the distributor is spraying asphalt. To check the bitumeter, a distance of 500 feet to 1,000 feet is marked off accurately on a straight and level length of road. The distributor is driven at constant speed over this length and the trip is timed with a stopwatch. Then the speed in feet per minute is calculated and compared with the bitumeter dial reading recorded during the run. This procedure is repeated for a number of other speeds, bracketing the speed to be used for spraying.

Errors found at the various speeds are tabulated or plotted on a graph so they can be readily applied when using the distributor. The bitumeter when used must be kept clean to ensure accurate registering of the truck speed. A build-up of asphalt on the wheel will produce an error.

## Traffic Control

Traffic control is important and must be maintained throughout the work area. High speed traffic over a fresh seal coat displaces aggregate, causing bleeding of asphalt. Traffic should be allowed only in the lane not being sealed. When work is completed, traffic speed should be maintained at less than 35 mph, or the legal speed if under 35 mph, until the asphalt sets. Warning signs, flag persons, and pilot cars are essential for traffic control. Route trucks hauling aggregate to the aggregate spreader in a direction opposite of the seal coat operation. This prevents loaded trucks being turned on freshly placed seal coat.

Some emulsions such as High Floats may require up to 24 hours of traffic control or until the first sweeping occurs. This is in areas of high volume traffic or areas where vehicle weight exceeds the normal load range.

## Application of Asphalt

It is very important that the correct amount of asphalt be applied to the surface, as too much or too little asphalt will cause a slick roadway surface. If not enough asphalt is shot, the rock will ravel off leaving a surface rich in asphalt. If too much asphalt is shot, it will flush to the surface.

Many factors are used to determine the amount of asphalt to shoot, including the grade of asphalt, size of aggregate, condition of roadway surface, and traffic. After a rate of application is determined, a shot of asphalt should be put down, covered with aggregate, and rolled. A field check should be made by checking to see that the asphalt depth is approximately three-quarters of the way up on the firmly placed aggregate. Any adjustment needed should be made in the asphalt application rate at this time. A field check should be performed periodically during the day to assure correct application rates are maintained throughout the entire project.

Rough and unsightly transverse joints can be avoided by starting and stopping the asphalt spread on building paper. The distributor, traveling at the correct speed for the desired application rate, starts spraying on the paper so that a full, uniform application of asphalt results when reaching the exposed surface. The use of smaller, more absorptive aggregate at the ends has been successfully used instead of paper.

A longitudinal joint is usually unavoidable because traffic lanes must be maintained. If possible, longitudinal joints should be made along the centerline or center of lane of the pavement and never in the wheel tracks. To prevent aggregate from building up on the longitudinal joint, the edge of the aggregate spread should coincide with the edge of the full thickness of applied asphalt. This allows a width where asphalt is present in partial thickness, due to outside nozzle spray, that can be overlapped when asphalt is applied in the adjacent lanes.

## Spreading Aggregate

All aggregate required for the planned spread should be on hand before starting. It should be dampened if necessary, as described in the section on Material Selection. When the distributor moves forward to spray asphalt, the aggregate spreader should follow immediately behind it. The asphalt must be covered as soon as possible, otherwise the cooling of the asphalt will prevent good adhesion between asphalt and aggregate. It is important that the aggregate be spread uniformly and at the proper rate of one rock thickness. Marking the length that each truckload of aggregate should cover aids in controlling distribution.

## Chip Spreader Calibration

The following is a step-by-step procedure on how to calibrate your chip spreader and calculate the application rate.

1. Construct a one square yard shallow box or tarp, with shallow and narrow sides.
2. Place the box/tarp in the middle of the roadway a minimum of 50 feet in front of the chip spreader.
3. Get the chip spreader up to speed and apply chips over the top of the box/tarp.
4. Remove the box/tarp with the chips from the road.
5. Find an accurate materials scale. If in the field, the scale must be leveled and checked.
6. Place the chips from the box/tarp in a small bucket and weigh the bucket with the chips.
7. Empty the chips out and weigh the empty bucket.
8. Subtract the weight of the empty bucket from the weight of the bucket with the chips.
9. Since you had a one-square yard box/tarp, the weight from Step 8 is your pounds per square yard of chips.
10. Repeat the process at two to three gears and two to three RPM or speeds. You can then develop a chart.

Tons of Aggregate Required Per Mile for Various Widths and Rates							
Spread Rate	Spread Width (In Feet)						
	8	9	10	12	16	18	20
lb/yd <sup>2</sup>	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile
5	12	13	15	18	23	26	29
10	23	26	29	35	47	53	59
15	35	40	44	53	70	79	88
20	47	53	59	70	94	106	117
25	59	66	73	88	117	132	147
30	70	79	68	106	141	158	176
35	82	92	103	123	164	185	205
40	94	106	117	141	188	211	235
45	106	119	132	158	211	238	264
50	117	132	147	176	235	264	293
60	141	158	176	211	282	317	352
75	176	198	220	264	352	396	440
100	235	264	293	352	469	528	587
150	352	396	440	528	704	792	880
200	469	528	587	704	939	1056	1173
250	587	660	733	880	1173	1320	1467
300	704	792	880	1056	1408	1584	1760

To Convert From	to	Multiply By
Feet	metres	0.3048
lb/yd <sup>2</sup>	kg/m <sup>2</sup>	0.54292
tons/mi	Mg/km	0.563698

**Note:** The aggregate weight may vary a couple of pounds if the chips are wet.

## Chip Spreader

Chip spreaders kick the aggregate backward or drop the aggregate straight down to reduce aggregate rollover and reduce the degree to which the aggregate picks up on vehicle tires after the section has been opened to traffic. The spreader is a variable width machine and calibrated on pounds per square yard. Dump trucks work in combination with the chip spreader to achieve a uniform application of aggregate.

## Rolling

Rolling seats the aggregate in the asphalt and promotes the bond necessary to resist traffic stresses. Pneumatic tired rollers should be used on all seal coat jobs to give uniform ground pressure over the entire area to achieve proper embedment of the aggregate in the asphalt binder. Steel wheeled rollers tend to compact only high spots and can fracture soft aggregates.



Rolling should begin immediately after the aggregate has been distributed and should continue until the aggregate is properly seated in the binder. Rolling should begin at the outer edge of the treatment and proceed in a longitudinal direction, working toward the center of the road. Each trip should overlap the previous trip by about one-half the width of the front wheels. As soon as the asphalt has a definite set or hardening, rolling should be discontinued, to prevent the bond between the surface and aggregate from being broken by the roller.

Rollers should be operated at slow speeds (4 to 6 mph) to set the rock, not displace it. The number of rollers required for a seal coat project depends on the length of the operation. It takes two to four passes of the roller to set the rock. These rollers should have tire pressures of (45) psi or more.

Loose aggregate should be swept along the longitudinal joint and from the uncovered lane prior to application of asphalt. Brooming loose aggregate on a completed sealed surface should be done as soon as practicable, and during the cool part of the day, to minimize flying rock problems.

Relying on traffic to seat the aggregate has been successful, if speed is controlled, but using rollers gives better control and improves the chances for success.

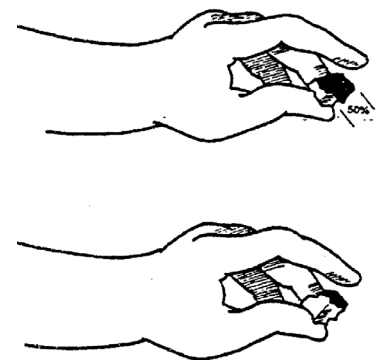
### Spreading of Fines or Choking - Optional

The need for applying fines will vary with the types of emulsions used and application rates. Those rates must be closely monitored. The most common material used for choking is  $\frac{3}{8}$ " to #10 or  $\frac{1}{4}$ " minus maintenance sand. In urban areas clean masonry sand can be used. Spreading these fines on a seal helps fill the voids, key the stone, reduces the chances of bleeding, and stops the squeezing and tracking of asphalt. The application of these fines prior to the roller, or after the roller depends on the types of emulsions used, and the location of the project. Fines application should not cover the coarse aggregate but merely fill the voids. The spreading of fines could be achieved by using a Hopper Sander with a mid mount spinner. This vehicle may be placed before or after the rollers depending on the type of operation.

### Post-Seal Inspection

The embedment of the aggregate into the asphalt should be checked a day or so after the construction of the seal coat. Remove several of the largest stones and determine if the 50 percent to 70 percent embedment has been obtained.

If an inadequate application of asphalt was applied, a fog seal can enrich and tie down the seal rock. A diluted CSS-1 (usually 50/50) is applied at the rate of .1 to .2 gallons per square yard of the dilution. (Application can vary depending on pavement texture, local conditions, and traffic). No cover aggregate is required; however, if a tighter seal is desired, a sand or 1/4" 0-0 cover may follow. Traffic should be controlled until the CSS-1 has cured.



## DOs of Seal Coating

- **Do** turn spray nozzles so that fans are at proper angle to spray bar, so sprays do not touch or merge.
- **Do** check bar height at start of each shot to determine ground-to-nozzle distance over entire bar length.
- **Do** check spraying pressure so as to give constant uniform spray. Pressure too high will cause spray to fog and distort, pressure too low will cause spray to sag with heavy edges and pronounced longitudinal streaking.
- **Do** heat asphalt to upper part of spraying temperature range to eliminate heavy edge that is characteristic of all fan type sprays.
- **Do** keep spray bars in proper working order by regular cleaning and inspecting of strainers. Clean spray bars after each day's operation.
- **Do** keep aggregate stockpiles clean and free of contaminants.
- **Do** clean out tank thoroughly when changing asphalts from emulsified to cutback asphalts or from cationic to anionic emulsions.
- **Do** keep equipment on the same side of the roadway that the sealing operation is on, so traffic flow is not impeded.
- **Do** cover shot as soon as possible and roll immediately to ensure a good bond.

## DO NOTs of Seal Coating

- **Do not** use worn nozzles or ones that have mechanical imperfections.
- **Do not** heat asphalt material above maximum temperature range, which would cause spray patterns of the fans to be uneven.
- **Do not** use asphalts that are too cold. Material will be too viscous and cause narrow spray fan, and materials will not flow together.
- **Do not** try to seal a wet or dirty road surface.
- **Do not** try to seal coat if air or road surface is too cold. Don't seal when windy.
- **Do not** make shots too long before applying aggregate.
- **Do not** turn equipment on a fresh patch.

## Blade Mixed Asphalt Mix

Blade mixing of asphalt cold mixes is an economical and versatile method of producing material for construction or repair of highway pavement. High production rates are possible with a comparatively low expenditure, and entirely satisfactory pavements can be achieved with blade mixed cold asphalt. However, proper attention must be devoted to ensuring uniform quantities of aggregates, uniform aggregate gradation, and correct, uniformly applied quantities of asphalt are combined into the final mix design.

A wide variety of aggregates ranging from well graded crushed rock to silty sands can be mixed satisfactorily by cold blade methods. The optimum results will be obtained by using a uniformly graded manufactured aggregate with a maximum particle size of ½ inch or less and not more than 10 percent passing the No. 200 sieve.

Emulsified or cutback asphalts may be used in the production of cold mixes. Up to 3 percent surface moisture may be required on aggregates for successful mixing with emulsified asphalts and subsequent compacting of the mixture. The surface moisture of aggregates should be as low as possible if cutback asphalts are used.

Well graded mixes are made using an asphalt with a fairly slow rate of curing such as MC, SC, SS, or CSS. Open graded mixes are made with a faster curing asphalt such as MC or CMS, or RC if it is to be spread and compacted immediately. Asphalt cold mixes which are to be made and placed into stockpile for future use are made with an MC or SC asphalt of 250 or 800 grade.

Prior to beginning the mixing operation, a permanent base pad must be prepared at the site upon which the cold mix will be made. The pad should be reasonably level, 3 to 4 feet wider than the distributor spray bar, and must be surfaced with compacted hot or cold asphalt mix. The length of the pad can vary depending upon conditions but should be approximately 400 feet if possible.

The cold mix is made in batches, the size of which will depend upon the capacity of the distributor and the desired asphalt content. For a uniform manufactured aggregate of ½ inch to 0 inch gradation, with a desired asphalt content of 5 percent and using a 1,000 gallon distributor, the batch size will be approximately 60 cubic yards.

Using a truck and tail gate or chip spreader, a layer of aggregate the width of the distributor spray bar is uniformly spread upon the length of the base pad at a rate of approximately 50 pounds per square yard. Heated asphalt is then shot over the layer of aggregate at a rate calibrated to yield the desired asphalt content. The amount of asphalt required will depend on the gradation of the aggregate and will normally range from 4 to 7 percent by weight of the completed mix. Successive layers of aggregate and shots of asphalt are placed one on top of the other until the batch is completed.

Mixing is accomplished by turning and blending the mixture with a grader. If several batches are being produced for stockpiling and production is a factor, the mixing is more efficiently accomplished by using two blades working in opposite directions. Well graded mixes will require a relatively greater mixing effort to coat all of the particles evenly than will be required for open graded mixes. Mixing should continue until a thoroughly uniform mixture is produced. The completed mix is then windrowed and picked up by a front-end loader and placed into stockpile.

Stockpiled mixes made with MC or SC cutback asphalts should be allowed to cure out for a period of time before the mix is used. Cure time varies depending on weather conditions but will normally be approximately two weeks.

## Handling Emulsified Asphalts

- DO** When heating emulsified asphalt, agitate it to eliminate or reduce skin formation. Agitation also prevents the asphalt lying next to the heating chamber from becoming overheated and boiling.
- DO** Protect pumps, valves, and lines from freezing in winter. Drain pumps or fill them with anti-freeze according to the manufacturer's recommendations.
- DO** Blow out lines and leave plugs open when they are not in service.
- DO** Use pumps with proper clearances for handling emulsified asphalt. Tightly fitting pumps can cause binding and seizing.
- DO** Use a mild heating method to apply heat to the pump packing or casing to free a seized pump. Discourage the use of propane torches.
- DO** Warm the pump to about 150 F (65 C) to ease start-up.
- DO** When a pump is to be out of service for even a short period of time, fill it with No. 1 fuel oil to ensure a free start-up.
- DO** Before diluting grades of emulsified asphalt, check the compatibility of the water with the emulsion by testing in a flask.
- DO** If possible, use warm water for diluting and always add the water slowly to the emulsion (not the emulsion to the water).
- DO** Avoid repeated pumping and recycling, if possible, as the viscosity may drop and air may become entrained, causing the emulsion to be unstable.
- DO** Guard against mixing different classes, types and grades of emulsified asphalt in storage tanks, transports, and distributors. For example, if cationic and anionic emulsified asphalts are mixed, the blend will break and separate into water and coagulated asphalt that will be difficult to remove. Because it is hard to determine visually the difference between various emulsified asphalts, always make a trial blend of the newly-delivered emulsion and the stored emulsion before pumping off. Check the trial blend for compatibility.
- DO** Place inlet pipes and return lines at the bottom of tanks to prevent foaming.
- DO** Pump from the bottom of the tank to minimize contamination from skinning that may have formed.
- DO** Remember that emulsions with the same grade designation can be very different chemically and in performance.
- DO** Haul emulsion in truck transports with baffle plates to prevent sloshing.

- DO** Mix by circulation, or otherwise emulsions that have been in prolonged storage may not be the proper consistency, as emulsions tend to separate when stored for extended periods.
- DO NOT** Use tight-fitting pumps for pumping emulsified asphalt; they may “freeze.”
- DO NOT** Apply severe heat to pump packing glands or pump casings. The pump may be damaged and the asphalt may become even harder.
- DO NOT** Dilute rapid-setting grades of emulsified asphalt with water. Medium and slow setting grades may be diluted, but always add water slowly to the asphalt emulsion. Never add the asphalt emulsion to a tank of water when diluting.
- DO NOT** Recirculate emulsified asphalts for too many cycles. They tend to lose viscosity when subjected to pumping. Also, air bubbles may become entrained which would render the emulsion unstable.

*Note:* Reprinted from Asphalt Institute’s/Asphalt Emulsion Manufacturers Associations: *A Basic Asphalt Emulsion Manual*. Please refer to this manual for additional information.

