

PAVED SURFACES

08.01 GENERAL MATTERS RELATING TO MAINTENANCE

This manual is intended for internal guidance only and is not intended to create a legal or moral duty. Supervisors have discretion, based upon their expertise and the particular circumstances, to deviate from this manual and to conduct additional research or receive input from experts in other areas, as needed.

08.01.01 TYPES OF PAVED SURFACES

The information contained in this chapter is intended to serve as a guide in maintaining the various types of paved surfaces in use in West Virginia. In general, paved surfaces include pavements of portland cement concrete, pavements of bituminous concrete and so-called low type bituminous surfaces.

A pavement of portland cement concrete may be either plain or reinforced with steel bars or wires. The plain type is found only on light traffic or older roads. At the present time, most old pavements of plain concrete on heavy traveled roads have been overlaid with hot mix bituminous concrete.

A pavement of bituminous concrete is usually composed of a dense graded asphaltic mixture having a high degree of stability. Such a pavement is usually laid on a flexible base consisting of suitable granular material. A pavement of bituminous concrete may also be used as an overlay on a rigid base, such as an old portland cement concrete pavement.

A low type bituminous surface may consist of a surface treatment, penetration macadam, a road mix, or a plant mix. Such surfaces are very satisfactory for low traffic volume roads on which vehicle weights are generally light. A low type surface may be applied to an old bituminous road that needs to be reconditioned; or it may be laid on an untreated granular base, a soil-cement base, an asphalt stabilized base, or a suitable base of practically any other type.

08.01.02 IMPORTANCE OF MAINTENANCE OF PAVED SURFACES

Every road with a paved surface represents a substantial capital investment; therefore, the highest standards of maintenance are warranted for the protection of that investment. The policy of the West Virginia Department of Highways in maintaining a paved surface of any type is to make necessary repairs by using, when feasible, a comparable material to that used in the original construction and make necessary repairs before they become major.

08.01.03 RESPONSIBILITY FOR MAINTENANCE

The highway user expects a smooth riding surface on all paved roads; therefore, it is the continual task of maintenance forces to attain this objective. It may be

necessary, even under adverse winter conditions, to place some type of temporary patching to preserve the desired riding quality of the highway.

08.02 MAINTENANCE OF BITUMINOUS CONCRETE PAVEMENTS

08.02.01 TYPES AND CAUSES OF DEFECTS

08.02.01.01 FAILURE OF FLEXIBLE BASE

A flexible base constructed of crushed stone, gravel or slag may fail for any one of several reasons. Among these reasons are: 1) faulty gradation of the aggregate; 2) insufficient thickness of the base; 3) weakness of the subgrade on which the base rests; and 4) base saturation resulting from inadequate drainage. The primary cause of failing base is generally inadequate drainage.

Usually failures are caused by an unforeseen increase in traffic loads and volume or by infiltration of water either from the surface, the edge of the road, or from underneath the base. Saturation of a plastic subgrade reduces its supporting strength. Moist clay in a subgrade can work upward into a granular base and destroy its stability. Moisture combined with an excessive amount of silt in a poorly graded granular base can weaken the base. Repeated cycles of freezing and thawing of moisture trapped in the base and subgrade is also very destructive. Thus, a fundamental rule for preventing failure of a flexible base is to keep the base and subgrade dry.

08.02.01.02 SURFACE FAILURE

Among the most common types of failures of asphaltic concrete pavements, the following merit special mention.

- 1) **Edge failure:** Cracking in an asphaltic concrete surface, starting at an outer edge and progressing back into the pavement for a distance which is sometimes as much as 12 to 18 inches, may be caused by insufficient thickness of the bituminous mat, excessive loads, lack of shoulder support or saturation of the base with water.
- 2) **Raveling:** Raveling or loosening of the particles of aggregate in an asphaltic concrete surface may be caused by insufficient asphalt, overheating of the asphalt during production, gradual absorption of asphalt by aggregate particles, progressive hardening or oxidizing of the asphalt as a result of the aging processes and exposure to air, sunlight and moisture, or poor construction methods.
- 3) **Potholes:** Several kinds of action that may lead to the formation of pot-holes in an asphaltic concrete surface are: Infiltration of water through open cracks in the surface; base instability resulting from lack of proper compaction during construction; saturation by infiltration of moisture; or a lean or open surface texture which encourages pitting, raveling or stripping of the asphalt films from aggregate particles.

- 4) **Alligator Cracking or Map Cracking:** The presence of irregular cracks in an asphaltic concrete surface almost invariably indicates some deep-seated trouble such as base failure resulting from saturation caused by poor drainage, poor compaction of the subgrade or base during construction, or excessive traffic loads. Such cracking is usually accompanied by some degree of settling or deformation of the surface. Since the cracks are connected and the surface looks like the skin of an alligator, such cracking is commonly known as alligator cracking.
- 5) **Subsidence and Distortion:** When subsidence and distortion of an asphaltic concrete surface occurs over a large area, it may be caused by inadequate compaction of the subgrade or base when the road was being constructed. Shoving may occur when brakes of heavy vehicles must be applied at traffic signals, stop signs, steep grades, etc.
- 6) **Bleeding and Instability:** The first indication of bleeding in an asphaltic concrete surface is a black, slick appearance of the mat in the wheel paths of vehicles. Bleeding is followed by instability, which leads to rutting, corrugating and shoving. The condition may be caused by one or a combination of causes, which include the following: 1) Excess asphalt; 2) Failure, when designing the mix, to provide sufficient space between the aggregate particles to allow for expansion of the asphalt binder in warm weather and for post construction consolidation of the mixture under traffic; or, 3) Accumulation of moisture beneath the surface mat resulting in destruction of the bond between the base and the mat (this condition is prevalent when inadequate prime coat was applied to the base before the mat was laid).
- 7) **Longitudinal and Transverse Cracking:** Cracks along and across an asphaltic concrete surface may be caused by movement of the subgrade or base, shrinkage of certain subgrade soils in very cold weather, or swelling or heaving of other types of soils. When a bituminous surface course is placed on a rigid or semi rigid base, such as one of portland cement concrete or soil cement, it is almost certain that any cracks which occur in the base will be reflected in the surface course.

08.02.02 CORRECTION OF BASE FAILURE

08.02.02.01 LOCATION OF FAILURE

Any failure in the base of an asphaltic concrete surface course is first indicated by some change in the appearance or riding quality of the surface. Once such a change is noted, careful investigation of the area in the vicinity of the change must be made.

08.02.02.02 PROCEDURE FOR MAKING REPAIRS

When the base of an asphaltic concrete surface fails, the best procedure for making the necessary repairs is as follows:

- 1) The entire area that is to be repaired is marked out on the road surface with keel or paint. The outline is made square or rectangular, and is located so that each edge of the finished patch will be parallel or at right angles to the direction of traffic.
- 2) By use of an air hammer with a spade bit or a suitable power saw, a cut is made through the asphaltic concrete surface course along the outline of the area to be repaired, and the material in that course is removed.
- 3) The base material is removed in a similar manner. However, the edges of the cut in the base are located 2 or 3 inches inside the edges of the surface cut to provide a shoulder of old base under the new surface material.
- 4) If it is necessary to install subsurface drainage or to replace unsuitable material in the subgrade, the next step is to remove the proper portion of the subgrade. The sides of the excavations are made perpendicular to the road surface, and the bottom is made level. The procedure for installing subsurface drainage is outlined in Chapter 4 of this Manual.
- 5) The holes in the subgrade are refilled with approved material that is placed in 4-inch lifts, each of which is then compacted.
- 6) The hole in the base is refilled with suitable material that is deposited in lifts or layers of the proper thickness and is compacted by using approved methods and equipment. The new material should be similar to that under the rest of the road.

The total thickness of the new portion of the base must be equal to or greater than that of the portions surrounding the repaired area. It is frequently considered necessary to provide a stronger base by increasing its thickness without changing the thickness of the surface course or the grade of the road. Thicknesses of lifts or layers that are considered acceptable are listed in Table 1. When hand or mechanical tamps are used, each layer of base material must be as thin as practical.

TABLE 1

ACCEPTABLE LOOSE THICKNESSES OF LIFTS FOR REPAIR OF BASE

<u>TYPE OF BASE</u>	<u>THICKNESS OF LIFT</u>
Bituminous Mixture	Up to 3 inches
Soil Cement	Up to 6 inches
Macadam	3 to 5 inches
Knapped Stone	3 to 7 inches
Stabilized Granular Base	Up to 4 inches

- 7) When a base is to be strengthened by increasing its thickness and the base material is good and of a type that can be reused, such as stone or slag, all the old material is removed carefully and bladed into a windrow on the shoulder. The subgrade is then excavated to the depth required to allow the addition of the extra base material. The necessary new material is added to that in the windrow on the shoulder, and the new base is constructed by placing the windrowed material in lifts of the specified thickness and compacting each lift until the top of the base is at the desired grade.
- 8) The surface course is replaced as described for correcting a surface failure in Section 08.02.03 of this chapter. Usually, a prime coat or a tack coat must be applied to the new base, as described in Section 08.03.01 of this chapter, before the surface course is laid.

08.02.03 CORRECTION OF SURFACE FAILURE

08.02.03.01 MARKING OUT AN AREA

The extent of the failed surface course area must be determined and the repair limits marked. Keel or paint can be used for marking small areas. If the area is large, it may be necessary to drive stakes or other markers along the shoulder. The finished edges of all patches should be parallel with or at right angles to the direction of traffic. Holes prepared to receive patching material must be neatly squared and the edges must be vertical.

08.02.03.02 EDGE FAILURES

When cracking occurs at the edge of an asphaltic concrete surface course, the cracked portion should be cut out and removed, and new surfacing material put in its place. The new material should be as much like the original material as possible.

It is also advisable to try to prevent recurrence of the failure. If the edge of the base has become saturated with water, placing stone drains through the shoulder might correct the trouble. If the shoulder is too low or too weak to provide adequate support for the edge of the pavement, the necessary shoulder repairs must be made at the time the surface course is patched. Ruts in the shoulder next to the pavement edge must be filled, because such ruts will hold water which soaks into the base and subgrade under the pavement causing edge cracking and failure of the surface course. These ruts are also hazardous to traffic. It may be necessary to clean the side ditch to improve drainage of the base. After this has been done, the base must be allowed to dry before the new surfacing material is placed and compacted.

08.02.03.03 CORRECTION OF RAVELING

Sometimes raveling of an asphaltic concrete surface is the result of the aging process due to air, sunlight and moisture affects on the asphalt in the mix which causes it to lose its adhesive qualities. To control raveling, a short term solution may be to cover the surface with a seal coat of the type described in Section 08.04 of this chapter. This type of seal will be placed only upon approval of the District Maintenance

Engineer. As a general rule, it will be an overall treatment, but in no instance, less than full lane width nor less than 500 feet in length of individual section.

08.02.03.04 REPAIR OF POTHOLE

The first step in repairing a pothole is to square up the hole. A power saw suitable for cutting asphalt or concrete, an air hammer fitted with a spade bit, or as a last resort an axe can be used for trimming the hole. The sides of the hole must be almost vertical. Any base material that has been lost before repairs are started must be replaced and compacted. Potholes must be located and repaired as expeditiously as possible to limit the Department's liability for damage which they might cause.

The pothole may be filled with hot or cold mix asphaltic concrete. When it is necessary to use cold-mix asphaltic concrete for patching during the winter months, the patches may later become unstable with resultant displacement. Unstable patches must be removed and the holes squared up and repatched, preferably with hot-mix material when it is available.

The patching mixture must be placed in layers that are compacted. The maximum permissible thickness of a layer after it has been compacted is 1-1/2 inches. The material must be shoveled (not dumped or dropped) into place, then it is spread in a uniform layer with rakes, lutes, or shovels. If a rake is used, it must be turned upside down so that the prongs (teeth) will be up and the back of the rake will rest on the material. Too much raking causes coarse particles of the mixture to work to the top of the patch. At no time should a pothole be repaired without some type of compaction equipment; either a steel wheeled roller, rubber tire roller, mechanical tamper, or hand tamper.

Getting a smooth riding patch requires care and skill. The finished patch must be 1/4 inch higher than the pavement around it to allow for the additional compaction which results from traffic. A patch that is too high can be as hazardous as a pothole and frequently is more damaging to vehicle suspension systems. Repair work must be continuously monitored to ascertain the quality of repair is acceptable.

08.02.03.05 REPAIR OF ALLIGATOR CRACKING

When alligator cracking or map cracking occurs in an asphaltic concrete surface, it must be decided if weakness of the base is the cause of the cracking. When the base is weak, a hollow or low place in the cracked surface just above the weak area can usually be seen. Surface water entering through the cracks can only make a weak base and subgrade weaker.

Steps must be taken to make sure that water does not enter the sides and bottom of the base. Some type of shoulder drain may be needed, or it may be sufficient to clean a side ditch or to fill ruts along the pavement edge.

In some cases, alligator cracking extends over a large area without much settlement of the base and the mat remains secured to the base. The base, therefore, appears to be strong enough. Asphaltic concrete pavement in this condition should be

programmed for resurfacing with hot laid asphaltic concrete. As a temporary measure to protect the base and subgrade, the application of a seal coat as described in Section 08.02.04 or 08.04 of this Manual may be advisable.

08.02.03.06 CORRECTION OF SUBSIDENCE AND DISTORTION

A depressed area is often found over a pipe culvert or at an approach to a bridge. Such a condition can be blamed on poor compaction of the backfill in the pipe trench or of the fill against the abutment of the bridge. Long waves in the surface of a pavement that is supported by an embankment often are due to improper placing and compaction of the fill material during construction. A depressed area may be brought to grade with a patching mixture. Unevenness in a twisted or distorted pavement may be corrected by bringing up the low places with a similar mixture. The best kind of mixture will depend on the thickness of new material needed. Suitable mixtures are described in Section 08.07. Uneven pavement can also be corrected with a suitable milling device.

The procedure for correcting a depressed area in an asphaltic concrete surface course is as follows:

- 1) The outline of the depressed area shall be marked with keel or paint. A straight edge or string line will be required to locate the limits of the low area.
- 2) A one inch deep and 9-inch wide notch shall be cut into the outer limits of the surface to be patched to heel-in the new material.
- 3) The surface of the existing mat shall be cleaned well with brooms or compressed air.
- 4) A thin tack coat should be applied if the surface is oxidized.
- 5) The patching mixture should be shoveled (not dropped or dumped) into place. It is not permissible to unload all the material in one large pile and to move it by lute or rake to all parts of the area being patched. The material must be deposited near its final position from shovels, and it is then spread and leveled with rakes, lutes and shovels.
- 6) The mixture in the patch must be compacted. The material near the edges of the patch must first be compacted with a hand tamp so that the patch will be held in position while it is being compacted with a roller or other compacting tool.

08.02.03.07 CORRECTION OF BLEEDING AND INSTABILITY

There are several ways to deal with a thick layer of asphalt that has "bled" to the surface of an asphaltic concrete mat. None of these, however, has been found completely satisfactory in all cases. One way is to mill the affected pavement with a suitable milling device and then place a complete overlay over the entire area removed.

This method is very useful if there are ripples or short waves in the surface of the area in which bleeding has occurred. This work is usually done by specialized State or District crews.

There is only one sure way to correct a surface that is unstable. The unstable portion must be removed completely and must be replaced with new paving mixture. In municipal areas having many traffic signals, a different paving mixture should be used to resist damage caused by heavy vehicles starting and stopping and by wheels moving in the same paths.

08.02.03.08 CORRECTION OF LONGITUDINAL, TRANSVERSE AND RANDOM CRACKING

The proper filling of cracks and joints in an asphaltic concrete pavement is one of the most important skills that can be learned by maintenance crew members. The big item in the cost of filling cracks and joints is labor. Usually, a special crew of well trained crew members will be assigned to do this work in an entire County or District.

Some important requirements in filling cracks and joints are as follows:

- 1) The crack or joint must be clean and dry. It has been proven that the combined use of sharp metal prods, hooks, power-wheel cutters and compressed air is essential.**
- 2) The correct grade of filler material must be used. The width of the cracks to be filled and the season of the year are factors to be considered when selecting material.**
- 3) A crack having a width less than 1/8 inch cannot be effectively filled. The proper season of the year is in the fall, after the hot summer weather has ended and before bad weather begins. As the surface cools, the cracks widen and can be cleaned and filled more easily.**
- 4) Overheating of the filler material must be prevented. It may be necessary to check with the District Maintenance Engineer to ascertain the highest temperature to which the material being used can be safely heated. A double boiler must be used for heating rubber asphalt compound (para-plastic).**
- 5) The filler material should be placed in the crack to a level 1/8 inch below the surface of the pavement. The use of too much filler not only is wasteful, but causes a sloppy and unsightly job. Narrow strips of paper or sawdust may be used as a cover when necessary to prevent traffic from tracking freshly applied seal material.**
- 6) At a transverse joint or crack in an underlying portland cement concrete pavement, the asphalt concrete surfacing may be not only cracked, but pushed up in a ridge or bump. This ridge may be removed by the use of a suitable milling device.**

08.02.04 SEALING ASPHALTIC CONCRETE

08.02.04.01 SLURRY SEALS

Where an asphaltic concrete surface is badly worn and cracked, a slurry seal may be used as a means of holding a worn surface together until a more lasting treatment can be applied. The purpose of a slurry seal is to correct surface defects and waterproof the pavement structure. It is not intended to make the pavement stronger. The primary objective of a slurry seal is to keep out water and extend pavement life.

As previously stated, the slurry will not be applied in an unsightly, irregular pattern. As a general rule, projects will be planned for overall sealing, and in no instance, for less than full lane width nor less than 500 feet in length of individual sections. All sealing projects of this intermittent or interval nature must first be approved by the Director of Maintenance.

The slurry, itself, is a mixture of fine aggregate, slow setting (SS) emulsified asphalt and water. The mixture is prepared in equipment designed especially for the purpose. A relatively free flowing "creamy" consistency is desired. The consistency is controlled by the amount of water used. As a guide for a trial mix, the following quantities of emulsion and added water for each 100 pounds of fine aggregate are suggested:

Asphalt Emulsion (SS-1) or (SS-1-h) - - 2 to 3 gallons
Water ----- 1 gallon

A slurry seal may have any thickness between 1/8 and 3/8 inch.

The mixture is spread on the surface of the pavement to the proper thickness by means of a squeegee box towed behind a truck. Most modern machines perform both the mixing and spreading operations as it moves along the surface to be sealed.

08.03 RESURFACING WITH BITUMINOUS CONCRETE

08.03.01 TYPES OF RESURFACING

08.03.01.01 DEFINITION AND PURPOSE OF RESURFACING

Resurfacing with bituminous concrete means placing a wearing course constructed of a bituminous mixture on an old pavement of portland cement concrete

or on an existing bituminous road. Such a wearing course is heavier and thicker than a surface treatment described in Section 08.04 of this Manual.

Uses of bituminous concrete resurfacing include the following:

- 1) To cover a concrete pavement which shows extensive cracking, spalling of the surface or settlement.

- 2) To cover a bituminous surface that shows an excessive amount of cracks, potholes or settlements.
- 3) To cover a bituminous surface where excessive raveling and pitting exists.
- 4) To give additional structural strength to an old pavement.
- 5) To improve the skid resistance of a pavement.
- 6) To improve the riding quality of a pavement.
- 7) To form the final step in widening a road.

08.03.01.02 THICKNESS OF RESURFACING MAT

Several types of mixtures of aggregate and bituminous binders are used for resurfacing.

The thickness of a bituminous resurfacing mat is usually at least 1 1/2 inches; however, when an old portland cement concrete pavement is being overlaid for the first time the minimum thickness should be 4 inches.

Occasionally, an old bituminous surface must be covered by something that is heavier and more durable than a surface treatment, but is not as heavy as a 1 1/2 inch mat. On such a road, the placing of a thin overlay has become common in recent years. The thickness of such overlays is not more than one inch. It is often 3/4 inch or even as thin as 1/2 inch. A thin overlay may cost a little more than a surface treatment; however, it has the following advantages:

- 1) The riding qualities of the road can be improved because small irregularities can be corrected.
- 2) A thin overlay is as effective as a surface treatment in sealing the road against water.
- 3) There are no loose stones on the finished overlay to be whipped up and thrown by fast moving vehicles.

A thin overlay is not suitable for use on an old portland cement concrete pavement. Cracks and joints in the old concrete will reflect through the resurfacing mat quickly if it is too thin. A resurfacing mat on an old concrete pavement is usually at least 4 inches thick. When the thickness of a mat is to be more than 2 inches, it is usually laid in two or more layers.

08.03.02 RESURFACING MIXTURES

08.03.02.01 MIXTURES FOR THICK MATS

In most cases hot mix will be used for a thick resurfacing mat. The aggregate will be a combination of sand and crushed gravel, crushed stone or crushed slag. If the thickness of the finished mat is to be at least 2 inches, the largest piece of coarse aggregate will be about one inch in size. A dense graded aggregate is best. The binder for a hot mix will be viscosity grade asphalt cement.

08.03.02.02 MIXTURES FOR THIN OVERLAYS

The mixture for a thin overlay will contain about the same kind of materials as are used for a thick mat, but the aggregate will be smaller. If the finished overlay is to be about 3/4 inch thick, the maximum limit for the largest piece of aggregate is 3/8 inch. If the overlay is to be about 1/2 inch thick, the largest piece of aggregate cannot be larger than 1/4 inch.

08.03.02.03 PREPARATION OF MIXTURE

A hot mix for any resurfacing mat must be made in a central plant. It is best to prepare a cold mix in a central plant; however, a mobile plant can be used in some cases, and it is possible to prepare a cold mix in place on the road. A road-mixed resurfacing mat is constructed by spreading the required aggregate on the road, spraying it with asphalt and mixing the materials with grader blades, harrows or pulvimixers.

08.03.03 PREPARING THE EXISTING SURFACE

08.03.03.01 PREPARATORY OPERATIONS

Before the placing of any type of bituminous resurfacing mat is started, the existing surface must be prepared properly. In suburban areas there are many other objects such as drainage and utility manholes, gas and water valves, etc. which must be adjusted to provide a smooth riding surface. When these items are not owned by the Department of Highways, the owner is required by law to move and/or adjust, within a reasonable time, the facilities as directed to accommodate the roadway work. It is the Department's responsibility to notify the owners, usually through the District Utilities Supervisor, of all intended work and the required amount of adjustments.

08.03.03.02 PURPOSE OF PRIME AND TACK COATS

A prime coat is an application of liquid asphalt sprayed onto an existing unpaved surface with a distributor. It serves several purposes: 1) It plugs small holes or voids; 2) it coats and binds particles of coarse aggregate; 3) it hardens or toughens the existing surface; 4) it increases adhesion between the surface to which the prime coat is applied and the overlaying bituminous material.

A tack coat is a very thin uniform application of liquid asphalt to an existing paved surface. The purpose of a tack coat is to obtain a surface to which a new course of asphaltic concrete will bond firmly.

08.03.03.03 APPLYING PRIME COAT

The material used for a prime coat is usually a medium setting asphalt emulsion (MS). The best material to use is one which will penetrate the upper part of the base and harden quickly to a firm surface without leaving a "skin" of the priming material on top. For a very dense, tight base which will not absorb the prime quickly, a thin grade must be used. In cool weather, it is necessary to use a thinner grade than that which could be used in hot weather. Liquid asphalt can be made thinner by heating; however, overheating can damage the material and create a safety hazard.

The practical temperature ranges for spraying commonly used materials are shown in Table 2.

TABLE 2

APPLICATION TEMPERATURES FOR BITUMINOUS MATERIALS

<u>TYPE AND GRADE OF MATERIAL</u>	<u>APPLICATION TEMPERATURE RANGE (DEGREES FARENHEIT)</u>
<u>ASPHALTS</u>	<u>SPRAY</u>
RS-1-----	70-140
RS-2 & HFRS-2-----	125-185
MS-1, MS-2, HFMS-1 & HFMS-2-----	70-160
SS-1, SS-1h-----	70-160
AEM-2-----	120-160
AEM-3-----	140-180
AEM-4-----	160-190
CRS-2-----	125-185
CMS-2-----	70-160

The application rate for bituminous prime materials usually ranges from 0.3 to 0.6 gal/s.y. The exact application cannot be specified, since it depends on the tightness of the base, the kind of material used and the temperature. The right quantity is the largest amount that can be absorbed by the base without leaving a skin on the surface. If the surface of the base is dusty, a light application of water just before the priming material is sprayed will help to get uniform absorption. If too much priming material is applied, the excess must be blotted up by scattering a light covering of dry sand, crushed stone or slag.

After the prime coat is applied, the material must be allowed to cure until it is no longer sticky or tacky. If the upper 1/4 or 1/2 inch of the base is fluffed up by the prime (this may happen with some types of base materials), the base must be rerolled as soon as the prime has cured.

08.03.03.04 MATERIALS FOR TACK COAT

When a pavement of portland cement concrete, brick or bituminous concrete is to be resurfaced with bituminous concrete, or when a base of one of these materials is to be covered with a surface course of bituminous concrete, it is usually necessary to prepare the existing surface by applying a tack coat. At the bottom of a steep grade or on an approach to a traffic light, for instance, the asphaltic surfacing must be tightly bound to the underlying surface so that it will not push up in waves.

Unless great care is taken in applying a tack coat, it may do more harm than good. A heavy tack coat will act as a lubricant between the old course and the new course and will cause movement of the new course instead of preventing it. Also, when a heavy coat is used, some of the material may bleed through the new course and make its surface soft and slippery.

The amount of bituminous material used for a tack coat must be sufficient to leave from 0.03 to 0.07 gallon per square yard of the area to be paved. After a tack coat has cured, it will be about as thick as a very thin coat of paint. It is better to apply too little tacking material than too much. With some types of surfaces a tack coat is not needed.

08.03.03.05 APPLYING TACK COAT

After the surface of the existing pavement (regardless of its type) has been patched where necessary and other corrective measures have been taken, the surface must be swept clean.

The only practical way of applying a thin coating uniformly is to use equipment which produces a fog spray. A regular truck mounted, power driven distributor with the correct nozzle size in the spray bar is appropriate for this operation. Check the distributor handbook for the distributor being used for the correct nozzle size. The height of the spray bar should be about 8 to 10 inches. If too much bituminous material is applied to any area, the excess must either be covered with enough dry sand to blot it or be removed.

Traffic must be kept off a tacked surface. If traffic is to be allowed to use a road during construction of a resurfacing mat where a tack coat is needed, the work must be done on half of the road at a time, only far enough ahead of the paving to permit curing.

Before the bituminous concrete resurfacing mat is placed, the tack coat must be allowed to cure without being disturbed until inspection shows that much of the solvent in the material has evaporated. When cured, the material will feel tacky. Curing may take longer in cool, cloudy weather than on a hot, sunny day. An emulsion may be used for the tack coat when traffic must be carried while the resurfacing mat is being placed. The surface that has been covered only with a tack coat must be protected until the binder course or surface course has been placed.

08.03.03.06 PREPARING PORTLAND CEMENT CONCRETE FOR RESURFACING

If an existing pavement of portland cement concrete is to be resurfaced with bituminous concrete, the steps that must be taken before the resurfacing mat is placed are as follows:

- 1) Slab sections that are badly broken and rocking should be removed and replaced. (Bituminous concrete may be used for these repairs).
- 2) Spalled areas at joints and in other places must be patched with the same mix that is to be used for the resurfacing mat.
- 3) Excess bituminous filler material must be carefully removed from over all cracks and joints. They will then be cleaned and resealed.
- 4) The entire surface will be cleaned and swept.
- 5) Catch basins, drop inlets, manholes and curb inlets must be adjusted to fit the new surface elevation where such facilities are located within the pavement section.
- 6) At points where it is obvious that water is trapped under the pavement, french drains through the shoulders should be provided.
- 7) Areas of slabs that have settled more than 1/2 inch must be brought to grade with a "leveling course." A light tack coat should be applied to the old concrete before material for the leveling course is spread.

08.03.03.07 PREPARING BITUMINOUS CONCRETE FOR RESURFACING

If the existing roadway has a bituminous surface, the following steps must be taken before it is resurfaced with bituminous concrete:

- 1) Sections of failed base must be removed and replaced with new base material.
- 2) Highway pavement profiling work will be completed as required along low curb sections and bridge decks.
- 3) Where the old surface is pushed up in a ridge over joints, it must be removed by pavement profiling.
- 4) Wide cracks must be filled with a lean mixture of sand and asphalt.
- 5) Potholes must be cleaned out and patched with a bituminous mixture similar to that being used for the resurfacing mat.

- 6) Catch basins, drop inlets, etc., must be adjusted to fit the new surface elevation.
- 7) The entire surface must be cleaned and swept.
- 8) All depressed or settled areas over 1/2 inch deep must be brought to grade with bituminous "scratch course."

08.03.03.08 PREPARING BASE FOR ROAD-MIXED MAT

Like any other resurfacing mat, a road-mixed mat must be placed on a firm base and must be of uniform thickness. Where the resurfacing mixture is to be prepared in place on the road, any loose or weak material in the existing pavement must be removed and all low places or holes must be filled before the resurfacing work itself is started.

Before a hole is filled care must be taken to remove all dust or dirt and to square the pothole. All patch material must be fully compacted in the hole. It may be tamped into the hole or rolled with a roller weighing at least 5 tons.

08.03.04 SPREADING AND ROLLING PREPARED RESURFACING MIXTURE

08.03.04.01 GENERAL REMARKS

The methods of spreading and compacting the mixture for a bituminous concrete resurfacing mat are the same as those used in constructing a new pavement. These methods are described in the Department's Standard Specifications. In order to get the best job possible, maintenance crews who are planning to place a resurfacing mat must study and follow the requirements of Section 401 of the Department of Highways' Standard Specifications (current edition) very carefully.

08.03.05 CONSTRUCTION OF ROAD-MIXED MAT

08.03.05.01 SPREADING AGGREGATE

Aggregate for road-mix must be clean and conform to the requirements, soundness and gradation as set forth in the Standard Specifications, Section 703 and Table 703.4 for gradations.

The final length of spread must be controlled in accordance with the Specifications. The rate of spread must be checked often by measuring the length and width of road covered by one or more weighed trucks. The rate of application, in pounds per square yard, of the stone must be checked and known in order to apply the correct amount of bituminous material.

08.03.05.02 APPLYING BITUMINOUS MATERIAL

Care must be taken to make sure that the bituminous material sent to the job is of the grade actually intended for use. A one quart sample must be removed for tests.

The width of the spray bar of the distributor must be adjusted so that all the bituminous material is applied to the aggregate and none on the old pavement.

The rate of application must be checked often by measuring the contents of the distributor before and after a run and computing the amount actually used per square yard of area covered. The application temperature must be between the limits given in Table 2 of this chapter.

08.03.05.03 MIXING MATERIALS

The objective of mixing the materials is to coat all aggregate surfaces with bituminous material. Mixing with the blade of a grader should continue until all aggregate particles are completely coated.

08.03.05.04 SPREADING MIXTURE

The mixture may be spread by a grader or a sled type drag. Care must be exercised in order that proper cross-section of pavement is obtained

08.03.05.05 ROLLING MIXTURE

It is usually best to start the breakdown, or first, rolling of road-mixed material with a three-wheeled roller. Except on a steep grade, the roller must be operated in reverse, so that the loose material will be tucked under the power-driven wheels instead of being pushed forward by the front roller. Rolling shall begin at the edges and progress toward the center, except on super elevations, when it shall begin at the low side and progress to the high side.

After the first rolling has been completed, the surface must be checked with the 10' straightedge and template. Every area that does not meet the required tolerance must be corrected.

08.03.05.06 SPREADING SEAL AGGREGATE

The objective of using seal aggregate on a road-mixed resurfacing mat is to provide a tight, smooth surface. The size of the particles of seal aggregate must be such that they will wedge tightly into the holes or voids left in the surface to which they are applied. Enough seal aggregate must be spread to cover the surface completely during rolling and then all loose material must be broomed off.

08.04 BITUMINOUS SURFACE TREATMENTS

08.04.01 CHARACTERISTICS OF SURFACE TREATMENTS

08.04.01.01 TYPES OF SURFACE TREATMENTS

Surface treatment is a broad term that covers several types of applications of bituminous material and aggregate. A surface treatment may be applied to almost any

kind of road surface except a pavement of portland cement concrete. A surface treatment has not proved satisfactory on portland cement concrete because of the tendency of the treatment to bleed. Surface treatments are classified as single surface treatments and multiple surface treatments.

A single surface treatment consists of a single spread of asphalt covered with a single spread of stone or chips. The finished treatment is less than one inch thick.

A multiple surface treatment is formed by applying asphalt in two or more spreads and covering each with a spread of stone or chips. The size of the stone used to cover the first application of asphalt largely controls the thickness of the finished mat, for the following reason. The size of the pieces of stone in each spread after the first one is smaller than the size in the previous spread. The idea is that the smaller pieces of stone will fit or "key" between the stones of the next larger size, and the completed surfacing will be stronger and denser. The finished thickness of a multiple surface treatment will generally be between one and two inches.

08.04.01.02 USES OF SURFACE TREATMENTS

A single surface treatment waterproofs the surface of a road, protects the surface from wear, and makes the surface more skid-proof. Such a treatment does not add strength to the road. A multiple surface treatment serves the same purposes as a single treatment and it may add strength of the road.

There are two main uses of surface treatments. Surface treatments are used as a wearing course on a granular base and to improve an older bituminous surfacing that has begun to wear under traffic.

The following items are of utmost importance in attaining a quality surface treatment project:

- 1) Correct application (gal/s.y.) of bituminous material
- 2) Correct height of the spray bar to insure uniform spread of bituminous material.
- 3) Correct rate of application (lb/s.y.) of aggregate
- 4) Spread aggregate immediately after the bituminous material is placed.
- 5) Aggregate must be compatible with the bituminous material
- 6) Clean, dust free aggregate with minimal moisture content.

A surface treatment may be used to give new "life" to the surface of a road. A surface treatment performs the job of sealing a road surface, prolongs the life of a dry and brittle asphaltic surface, and provides a wearing surface for the road.

08.04.02 DEFECTS IN SURFACE TREATMENTS

The types of defects that commonly occur in surface treatments are alligator cracking, potholes, raveling, bleeding and corrugations.

Alligator cracking in a surface treatment is usually caused by lack of adequate base strength. Some settlement or "dishing" almost always goes with such cracking.

Potholes in a surface treatment are caused by local surface failure, and the formation of a pothole in the surface treatment is usually followed by "chewing out" of the material under the surfacing by the wheels of traffic.

Raveling of a surface treatment is caused by a dry and brittle condition of the asphalt binder brought about by aging. In other words, the binder is no longer able to grip and hold the pieces of aggregate.

The bleeding of bituminous material to the surface of a surface treated road is usually caused by one of two conditions; too much bituminous material used in the treatment, or not enough aggregate applied to adequately cover the bituminous material.

Corrugations are surface ripples that look like the ridges on an old-fashioned washboard. They are sometimes found on a road on which a mat of some thickness has been built up by a number of surface treatments over a period of time. The mat becomes rippled because it is unstable and moves under the pushing action of traffic. The usual cause of the instability is excessive bituminous binder.

08.04.03 CORRECTION OF DEFECTS AND FAILURES

08.04.03.01 PRELIMINARY STUDY

It is important to keep in mind that, for the most part, the following remarks apply to roads that are constructed by the application of one or more surface treatments on a granular base. The methods of repairing bituminous concrete pavements that have received slurry seal coats are the same as those described in Section 08.02.

When a failure occurs in a surface treatment, the first step is to determine the extent of the failure. The next step is to outline the area of the surface to be repaired with chalk, paint, or keel as described in Section 08.02.03.01.

08.04.03.02 REPAIR OF ALLIGATOR CRACKING

If the area in which alligator cracking has occurred is small, and the "dish" or settlement is not very deep, satisfactory repairs can be made as follows: The surface is cleaned with brooms or compressed air, and, an even coating of bituminous material is applied and covered at once with chips of stone or gravel, crushed slag or sand. The kind of cover to use will depend on the depth of the "dish" and the type of bituminous material used. It is important to make sure that the existing surface is dry and that

there are no loose particles. It must be kept in mind that this type of repair does nothing to correct the lack of support beneath. The treatment merely helps to keep surface water from getting to the weak base to make a bad condition worse and brings the low spot back up to grade.

If there are signs that clay or other material is working up through the cracks, or if the surface is loose, more extensive repairs should be made. The old cracked mat must first be removed. The base must be examined for water and clay that may have worked up from the subgrade. If water and clay are found, it is necessary to remove the base all the way down to the subgrade. The source of the water must be found and good drainage must be provided. After defects in drainage have been corrected, new base material is placed and compacted. The most suitable compaction method will depend on the size of the failure. The top of the new base after compaction or the top of the old base (if it did not have to be removed) should be about one inch lower than the mat around the patch.

The surface of the new or old base must be lightly primed with about 1/4 gallon per square yard of suitable bituminous material. After the prime has been allowed to cure, a double surface treatment should be applied to bring the patch up to grade.

08.04.03.03 REPAIR OF POTHoles WITH SURFACE TREATMENT

The sides and bottom of each pothole in a surface treatment must first be cleaned. The hole must then be shaped to form a square or rectangle whose sides are parallel or at right angles to the direction of traffic, and the edges neat and as nearly vertical as possible. The trimming of potholes in a surface treatment can be done with an ax, but the preferred method is to use a power circular saw equipped with a blade suitable for cutting pavement materials. The patch may be made with surface treatment or penetration macadam methods.

Enough material must be used to bring the surface of the patch about 1/4 inch above the level of the rest of the pavement to allow for further compaction by traffic.

There may be times when it will be necessary to use premixed material for repairing the base.

08.04.03.04 REPAIR OF POTHoles WITH PENETRATION MACADAM

When a pothole is to be patched with penetration macadam, the entire operation is similar to the construction of a new pavement of penetration macadam. A layer of aggregate of substantial thickness is spread uniformly and compacted. Sufficient asphaltic binder is applied to the surface to penetrate the entire depth of compacted aggregate. The course of penetration macadam is then covered with a seal coat. This method of patching is used frequently because the procedure is quick and easy, and the work can be done with a minimum of equipment.

After the hole has been properly cleaned and shaped, a layer of the largest aggregate AASHTO size #3, 4, 56, 57 or 67 is placed. The dry aggregate in the hole is

thoroughly keyed by tamping or rolling and bituminous binder is sprayed or poured on the consolidated aggregate.

After the first coat of bituminous material has been applied, the surface voids must be filled (choked) with clean AASHTO sizes #7, 8, or 9 aggregate. It is important that the amount of choke aggregate be only sufficient to fill the surface voids. The course must then be rolled or tamped. During the rolling operation, the choke aggregate must be moved about with brooms or a sweeper to assist in obtaining a uniform distribution and to assure the complete filling of the surface voids. Excess aggregate must be removed before the seal coat is applied. A seal coat application and a final rolling completes the job. The bituminous material used in the seal coat may be of the same kind as that used in the penetration-macadam course.

08.04.03.05 REPAIR OF RAVELING

Raveling of a surface treatment can be corrected by applying a new single surface treatment to the raveled area. The existing surface must be thoroughly cleaned. The treatment is applied by shooting asphalt on the raveled areas, spreading cover aggregate (AASHTO #8, #9 or sand) uniformly over the asphalt with the aid of hand brooms and rolling.

Care must be taken to insure that the amount of aggregate used is sufficient to protect the bituminous binder, but is not excessive.

08.04.03.06 CORRECTION OF BLEEDING

By making a detailed inspection of each portion of surface treatment that is bleeding, it will usually be possible to determine whether bleeding is caused by loss of cover aggregate or by the use of too much asphalt. In either case, enough asphalt must be available to hold a new cover.

When a defect of this kind is to be corrected, the best time to perform the work is during the middle of a hot day (the higher the temperature, the better the results). A suggested method of treatment is to apply AASHTO #8 or #9 aggregate, or sand with a truck mounted mechanical spreader.

Where surface treatment is just beginning to show a tendency to bleed, as indicated by black marks along the wheel tracks, the necessary correction can frequently be made by using sand to blot up the excess asphalt. In such a case, the sand must be spread and the rolling must be done during the hottest part of the day.

08.04.03.07 CORRECTION OF CORRUGATIONS

The most satisfactory method of correcting corrugations in a surface treated road on a granular base is to scarify the material to a suitable depth, reshape and recompact the loosened material as part of the base, and apply a new multiple surface treatment.

When corrugations develop in a surface treatment that is supported on a base which is stabilized with soil cement or asphalt, the method of correcting the defect is to remove the surface, thoroughly clean the base to remove all loose material, and apply a new multiple surface treatment.

08.04.04 BITUMINOUS MATERIALS FOR SURFACE TREATMENTS

The RS and MS grades of emulsified asphalt are usually used for surface treatment work because they cure quickly and the cover aggregate is gripped by the asphalt before it can be whipped off by traffic. The grade to be used depends mainly on the season. In hot weather, MS grades may be used. However, in cool or hot weather, RS grades of material will give the best results. There are two general types of emulsions called anionic and cationic.

The particles of asphalt floating in the water part of an anionic emulsion are attracted to, and will easily coat limestone and some other aggregates. An anionic emulsion may not work well with gravel which contains silica. Anionic emulsions are quite sensitive to weather conditions and an emulsion of this type may not "set" or "break" during damp weather.

The asphalt particles in a cationic emulsion are attracted to, and will coat, gravel that contains silica. It has been found that cationic emulsions give good results with a wide range of aggregates. Cationic emulsions are less sensitive to weather conditions than anionic emulsions.

The two types of emulsions are opposite in nature. Care must be taken to prevent the mixing of an anionic emulsion and a cationic emulsion. When mixed the emulsions will "break" instantly and the asphalt will become unmanageable.

A tank, distributor or other piece of equipment that has been used for one type of emulsion must be cleaned thoroughly before it is used for the other type material.

08.04.05 EQUIPMENT FOR SURFACE TREATMENTS

08.04.05.01 TYPE OF EQUIPMENT USED

Success in applying a surface treatment depends to a large extent on the equipment used, its condition and the way in which it is handled. All equipment must be in good operating condition and properly adjusted. It is the responsibility of the Crew Leader assigned to surface treatment work to make a routine daily inspection of each piece of equipment under his jurisdiction, and to insure that all equipment is maintained properly. The most important single check is to make sure that every piece is cleaned at the end of each day's work.

08.04.05.02 DISTRIBUTOR

The most important piece of equipment on a surface treatment job is the distributor for applying the bituminous material. It is made specifically to apply liquid

asphalt at a uniform rate to the road surface regardless of variation in the grade or profile. Figure 08-1 shows a sketch of a typical truck mounted distributor.

The operator of a distributor must be properly trained and experienced. He should have knowledge of the manufacturer's recommendations in regard to nozzle size and adjustment, pump pressures, burner operation, and spray bar height settings. The manufacturer's calibration chart must be kept in the distributor at all times.

At the beginning of each day's work, the operator of a distributor or asphalt maintainer should thoroughly check and verify the following:

- 1) Are the heaters and pumps functioning properly?
- 2) Are all gauges and measuring devices functioning properly?
- 3) Is the spray bar clean and properly set at the correct height to produce an even spread?
- 4) Are the nozzles clean, free of "burrs" and at the correct angle?
- 5) Is the hand hose clean and operating properly?
- 6) Is the bitumeter wheel free and functioning properly?

Before a distributor is loaded with hot asphalt for the first time each year, it must be flushed out with a suitable solvent. If even a very small amount of water is trapped in a pipe or a valve, serious boiling and foaming will occur when hot bituminous material comes in contact with the water.

If the manufacturer's charts or instructions are not furnished with the equipment when it is assigned, the County Maintenance Superintendent is expected to notify the Equipment Division and ask for the necessary information. If the Equipment Division does not have the information, it must be obtained from the manufacturer.

08.04.05.03 AGGREGATE SPREADERS

The aggregate spreader is second in importance to the distributor in applying a good surface treatment. A suitable aggregate spreader that is operated properly will conserve aggregate and produce a uniform spread. There are various types of spreaders. The simplest being fixed vanes attached to the tail gate of the aggregate truck. The most efficient type is self-propelled and is equipped with a mechanical feeding device.

Mechanical aggregate spreaders contain hoppers mounted on pneumatic tires. Each has a built-in distribution system to ensure a uniform spread of the aggregate across the entire lane width. Mechanical spreaders are either truck attached or self-propelled. In both types, the aggregate is dumped from a truck into a receiving hopper for spreading. The truck attached spreader contains an auger and a

roughened spread roll in the hopper that ensures a positive, uniform feed of material. The self-propelled unit has a similar feed mechanism. The self-propelled unit has the advantage of being able to follow closely behind the asphalt distributor with minimum stopping to change aggregate trucks. Mechanical self-propelled aggregate spreaders should be calibrated to apply the quantity of cover aggregate required for the project.

Usually the discharge hopper has a feed stop that can be closed or opened to adjust the width of spread in increments of one foot from the full width down to one foot.

The following check list must be used for each aggregate spreader on a daily basis.

- 1) Has the aggregate spreader been checked for proper operation?
- 2) Have all adjustments been made in accordance with the manufacturer's operating manual?
- 3) Have the hitches on all trucks been checked to make sure they may be connected quickly and positively to the spreader?
- 4) Has the rate of application of the spreader been checked?

08.04.05.04 ROLLERS

Proper seating of the aggregate particles is a very important operation in applying a surface treatment. There are several types of compactors, but the types generally used for surface treatments are pneumatic tired rollers and steel wheeled rollers. A self-propelled pneumatic tired roller is preferred for all surface treatment work. It is important that the same tire pressure be carried in all tires of the roller. The tire pressure should be between 60 - 120 pounds and the inflation pressure should

not vary more than 5 pounds between tires. Rollers must be inspected prior to each day of operation.

08.04.05.05 POWER BROOMS AND AIR COMPRESSORS

A power broom is useful for cleaning off a large area of a surface that will not need to be cut out and removed. Hand brooms or an air compressor that is fitted with hoses and blow nozzles are useful for cleaning of a small area of a surface where a patch is to be placed.

There are several types of rotary brooms that are either towed or self propelled.

Every compressor must be tested for proper operation.

08.04.05.06 MISCELLANEOUS EQUIPMENT

Various other pieces of equipment may also be required for surface treatment repair and construction. Among them are the following:

- 1) Mechanical tampers of the vibrating and impact types
- 2) Hand tampers
- 3) Hand brooms
- 4) Cutting tools, such as axes
- 5) Shovels
- 6) Trucks to haul equipment, material and personnel
- 7) Traffic-control devices

08.05 DETAILS OF APPLYING SURFACE TREATMENT

08.05.01 PRELIMINARY CONSIDERATIONS

All needed repairs to the existing surface must be made before the resurfacing operations are started. The weather has to be right, the surface must be clean, the materials must be on the job and the equipment in good working order.

Weather has an important role in the success of a surface treatment. It should be hot and dry while the new surfacing material is being placed and for as long as possible thereafter.

The surface to be treated must be cleaned immediately before the asphalt is sprayed. All hardened mud and other foreign matter must be removed, and the surface must be swept thoroughly with power brooms. Where shoulder material has

built-up on the edge of the roadway, a grader must be used to cut the shoulder back far enough to permit the entire roadway surface to be cleaned and sprayed.

The type of asphalt, the type of cover aggregate, and the rate of application of each material will be determined by the Maintenance Engineer before the materials are ordered. The delivery of materials to the job must be coordinated so that there will be no delays after the work starts. Enough bituminous material must be at the job or delivered to it to complete each day's work without undue delays. The number of trucks used for hauling aggregate must be ample to assure complete coverage of bituminous material with aggregate immediately after its application. The aggregate stockpiles must be built up in time to allow excess water to drain off.

At the end of each day's operation, the equipment must be inspected, serviced and cleaned. Equipment that is well maintained and clean seldom breaks down on the job.

08.05.02 SPRAYING ASPHALT

Before the spraying of bituminous material is started, a line must be established near the edge of the road in a manner suitable to guide the operator of the distributor. String, stakes, or rocks placed in line a uniform distance from the edge of the road will serve the purpose. The thermometer on the distributor must be checked to make sure that the bituminous material is at the correct temperature for application.

The length of the shot to be made must be determined by the amount of aggregate loaded and ready to be spread or the amount of asphalt in the distributor.

To determine the length, in feet, which can be covered by an available amount of aggregate, it is necessary first to find the net weight of material in each truck. Then the following calculations are performed:

Step 1: The total number of pounds of aggregate is multiplied by 9.

Step 2: The width of spread, in feet, is multiplied by the rate of application, in pounds per square yard.

Step 3: The result found in Step 1 is divided by the result found in Step 2.

When the amount of bituminous material to be spread is the governing factor in determining the length of the shot, the calculations are as follows:

Step 1: The number of gallons to be spread by the distributor is multiplied by 9.

Step 2: The width of the spread, in feet, is multiplied by the rate of application, in gallons per square yard.

Step 3: The result found in Step 1 is divided by the result in Step 2.

The number of gallons to be spread from a load is found by subtracting 50 gallons from the gallonage shown by gauging at the start of the run. This 50-gallon margin assures the full rate of application right up to shut off. If an attempt is made to use up all the material in the distributor, the pump will start to suck air near the end of the load, and the spread will be uneven.

The amount of bituminous material actually used for each shot may be measured in the following manner:

Before and after a shot, the distributor is stopped on a level area and a gauge stick is inserted through the dome down to the material in the tank. This operation is known as "sticking the distributor." The gallonage corresponding to the

measurements shown on the stick is then found from a table of volumes that is furnished with the distributor. If the distributor has a dial gauge the readings should be regularly checked for accuracy.

The temperature of the material can be read on the thermometer attached to the distributor.

The temperature at which the volume of bituminous material is usually computed for application or billing is 60°F. For that reason, it is necessary to convert the gallons measured by the gauge stick at the temperature shown on the thermometer to gallons at 60°F by referring to the conversion tables given in The Asphalt Institute's "Asphalt Pocketbook of Useful Information" or any number of other publications published or distributed by the industry.

If it is likely that the appearance of curbing, a culvert headwall, a bridge parapet, or some other structure will be marred by flying spray from the distributor, the structure must be covered with building paper before the run is started. Used building paper must be carefully removed for proper disposal.

08.05.03 TRANSVERSE JOINTS

Rough and unsightly transverse joints in a surface treatment can be avoided by starting and stopping the spread of bituminous material and aggregate on building paper. One length of paper is laid across the lane to be treated in such a position that the forward edge will be at the place at which the treatment will start. When the distributor reaches this paper, it must be traveling at the correct speed for the desired application rate. The flow will then be started. However, the material first discharged will be sprayed onto the paper; and by the time the distributor reaches the exposed surface, the spray bar will be making a full, uniform application. A second length of building paper is placed across the lane so that its near edge is exactly at the predetermined location of the joint. The clear distance between the starting and stopping strips of paper must be made equal to the length of lane to be covered by the shot. It is determined in the manner described in Section 08.05.02. The full flow from the distributor will be continued until the paper is reached, and any material discharged after the cut-off point will be sprayed onto the paper. In this way a

straight, sharp transverse joint can be obtained. Immediately after the aggregate spreader has passed over the paper, the paper must be removed for proper disposal.

For the next application, the first length of paper is placed on the previously laid treatment so that its leading edge will be about 1/2 inch back of the end of that treatment. This exposure will prevent a gap between the two spreads.

08.05.04 LONGITUDINAL JOINTS

The only way to eliminate a longitudinal joint in a surface treatment is to apply the treatment to the entire width of the area to be treated at one time. However, where a surface treatment is applied, it is usually necessary to allow traffic to use the road

and a longitudinal joint is unavoidable. Full width coverage with bituminous material will never be possible unless the distributor can apply full pressure to all parts of the spray bar and arrangements can be made to have the necessary aggregate cover spread immediately.

In order to prevent aggregate from building up at a longitudinal joint, the edge of the aggregate spread must coincide with the line along which the full rate of bituminous material has been applied. When the bituminous material is applied in the adjacent lane, there will be overlap of the area which was not fully covered. The aggregate is spread for the full width in the adjacent lane, leaving no build-up at the joint. The width of the bituminous material that is left exposed will vary. It will depend on whether the height of the spray bar is set for a double lap or for a triple lap and on the spacing of the nozzles.

The best location of a longitudinal joint is along the centerline of the roadway surface being treated. An established guide line must be used to assure a straight longitudinal joint.

08.05.05 SPREADING COVER AGGREGATE

All aggregate needed for the planned spread must be on hand before any of the bituminous material is applied. When the distributor moves forward to spray the bituminous material, the aggregate spreader must start. It is essential that the bituminous material be covered immediately. Otherwise, the increase in its viscosity which takes place during curing may prevent good wetting and binding of the aggregate. Another important requirement is that the aggregate be spread uniformly and at the proper rate.

Only aggregate which is in contact with the bituminous material can stick to the road surface. It is useless and wasteful to apply aggregate at a rate which would result in a thickness greater than the size of the largest particles. A very accurate and uniform application rate can be assured with a properly adjusted mechanical spreader. Another help in controlling the distribution rate is to lay off the length which each truck load of aggregate is expected to cover.

If too much aggregate is applied in some spots, the excess must be removed immediately with square pointed shovels. Where the initial application is insufficient, additional aggregate must be added. When the aggregate spreaders are adjusted properly, hand work will be held to a minimum.

08.05.06 ROLLING

Rolling seats the aggregate in the bituminous material and thus improves the bond which is necessary to resist traffic stresses. The cover material should be rolled immediately. The best type of roller for seating the aggregate without crushing is a heavy rubber tired roller that is self-propelled and has smooth treads with a tire pressure between 75 and 90 pounds per square inch. A steel wheeled roller may be used, based on manufacturer's recommendations, if a rubber tired roller is not available.

Rolling should continue until the cover aggregate has been properly seated in the bituminous binder. When the binder has taken a definite set, rolling should stop because the bond between the binder and the aggregate might be broken. Rolling must be started at the outer edge of the treatment and proceed in a longitudinal direction while the roller is moved toward the center of the road in stages. The path for each trip will usually overlap that for the previous trip by about one-half the roller width.

08.05.07 CONTROL OF TRAFFIC

Control of traffic through the work area is important while a surface treatment is being applied and for a short time after the construction has been completed.

A vehicle traveling over a fresh surface treatment at a high speed displaces the aggregate and produces a slick, black surface. Traffic must be detoured or allowed only on the lane not under construction. When work has been completed and the bituminous material has taken its initial set, the speed of traffic must be kept below 25 miles per hour until final set has occurred. The length of time required for final set will depend on the weather. Traffic must be directed through the work area in a manner designed to provide maximum safety for workers and the least possible interruption of the work. Traffic control must be provided throughout the job. The best way to control traffic is by means of warning signs, flagmen and a pilot truck that leads vehicles past the work. Traffic Control must be in accordance with Traffic Control Manual.

The movement of the hauling equipment also must be controlled. The aggregate trucks must be routed to the aggregate spreader in a direction opposite to that in which the surface treatment work progresses. This should eliminate turning on the freshly placed treatment. It may be necessary to designate a suitable place away from the newly treated area at which trucks will be required to turn around for the return trip to the stockpile. The job must be laid out so that the treatment starts at the point farthest from the aggregate stockpile and progresses toward the stockpile. Then the hauling trucks will not have to travel over the newly surfaced road.

08.05.08 MULTIPLE SURFACE TREATMENTS

When a road is required to carry a greater volume of traffic or when an attempt is made to provide some leveling, it may be necessary to use a double or triple surface treatment. Where two or more applications are used, the largest aggregate is placed in the first course and the aggregate in each succeeding course is smaller. The thickness of the layer of aggregate for each course, except the top one, should be made greater than the size of the largest particle in the course.

The steps in the construction of a multiple surface treatment are essentially the same as those for a single surface treatment, but the operations are repeated either two or more times. The procedure for a double surface treatment consists of the following steps:

- 1) Prepare existing surface by cleaning, priming, etc.
- 2) Apply the first course of bituminous material.
- 3) Place the first course of aggregate.
- 4) Roll the first course.
- 5) Apply the second course of bituminous material.
- 6) Place the second course of aggregate.
- 7) Roll the second course.

Time must be allowed for proper curing after each treatment.

For triple surface treatment, Steps 5, 6 and 7 are repeated for the third course.

A multiple surface treatment is frequently used on only a part of a road to raise low spots or to strengthen the edges of the pavement. When the edges of a pavement require thickening to reduce the crown or strengthen the road, the following method may be used: Bituminous material is applied to a strip 2 to 3 feet in width near each edge of the pavement and covered with AASHTO No. 67 aggregate. If necessary, a strip at least 1 foot wider may be treated with bituminous material and AASHTO No. 7 aggregate. After the leveling courses and strengthening have been applied, the entire pavement surface should be treated with bituminous material and covered with AASHTO No. 8 or 9 aggregate.

08.06 PAVEMENTS OF PORTLAND CEMENT CONCRETE

08.06.01 GENERAL FEATURES OF MAINTENANCE

Concrete pavements that have been built over the years vary in design, width, thickness, type of joints, type of reinforcement and material composition. The following applies to concrete surfaces in general.

Cleaning and sealing joints is the biggest single item to consider and perform in an effective preventive maintenance program.

To remain in good condition, a concrete slab must have strong uniform support from the soil or other material comprising the base. When that support is taken away by settlement, by scouring from water action, or is weakened by saturation, prompt action must be taken to remedy the situation or the slab will fail.

08.06.02 TYPES OF DEFECTS

The common defects found in pavements of portland cement concrete are: faulting joints, spalling joints, scaling surface, blow-ups, and map cracks.

08.06.02.01 FAULTING JOINTS

When the support of the concrete next to a joint is removed, settlement of the slab results in a "step-down" or fault. This loss of support may be started by water that leaks through a joint in the pavement and collects in the subgrade under the slab. When traffic loads cross the joint, the water and soil are forced up through the joint and to the side of the slab. This action is called "pumping." As the void under the slab gets larger, more and more water gathers, and the condition usually becomes worse. Finally the slab cracks because it is unable to carry the traffic weight without support, and a step-down, or fault, is formed at the joint.

If the cracks in the pavement, regardless of cause, are not sealed at once, water can find its way to the subgrade. Pumping then starts at that point and new cracks and faults are formed.

08.06.02.02 SPALLING JOINTS

Most spalling at joints is caused by poor construction practices. Some of the conditions that lead to spalling are the following:

- 1) A series of narrow bridges over an expansion joint have been formed by concrete or other rigid material, and pressure caused by expansion have been concentrated on small parts of the concrete slab at these joints. A portion of the concrete then breaks away from the slab.
- 2) Steel dowel bars at expansion joints which are not set parallel to the centerline and grade line of pavement surface will cause spalling when a large expansion occurs. They do not slide in the sleeve and will apply an oblique force. Often these bars are first set properly but are dislocated during concrete placement.
- 3) Joints are not properly formed and sealed.
- 4) Soupy, low quality mortar was used in finishing and edging a joint and along the edge of a slab, or the mortar in these areas was troweled too much.

08.06.02.03 SCALING

Scaling is a breaking up of the pavement surface caused by chemical action or improper construction. Chemicals used for ice control are the primary cause of scaling on portland cement concrete pavements.

08.06.02.04 BLOW-UPS

A blow up results when expansion of the pavement causes failure of an expansion joint during unusually hot summer weather. The presence of small spalls along the edge of the joint for the full width of the pavement generally indicates the

beginning of a blow up. This spalling may get worse slowly or the concrete may heave up suddenly. A sudden failure of this nature is called a "blow-up".

08.06.02.05 MAP CRACKING

Many older concrete pavements were built without steel reinforcement and without any means for controlling contraction of the concrete. Contraction cracks occur in these pavements in uneven or random patterns. In other cases, a pavement cracks because the concrete slab and/or the sub-base material do not have adequate strength to carry the heavy loads that now use the road. Random cracking caused by these conditions are referred to as map cracking.

08.06.03 PATCHING CONCRETE PAVEMENT

08.06.03.01 USE OF RESURFACING COURSE

When a concrete road has failed because the slab is too thin to carry heavy traffic, patching of the pavement will not be adequate. Before a large scale patching operation is planned, the cause of the failure must be determined. If it is found that the road is not thick enough to carry present traffic, it may be possible to strengthen the existing pavement by applying a resurfacing course of either portland cement concrete or asphaltic concrete. The old damaged pavement must be suitably prepared before the new overlay is placed. All rocking slabs must be corrected or replaced.

08.06.03.02 MARKING OUTLINES OF PATCH

The first step in patching portland cement concrete is to define the area or areas to be patched. How a patch will stand up under traffic depends on its shape, size and position in the pavement. It takes an experienced individual to decide on these details and to lie out and mark areas to be patched. Where settlement has occurred, a stringline or straightedge will be helpful in fixing the boundary of the area to be patched.

The outline of the patch must be square or rectangular, and each side must be parallel or at right angles to the direction of traffic. Where the failed section extends for the full width of the road, the work must be done so that traffic will be able to use one half of the road at all times. In extremely hot weather a cut completely across the pavement may be advisable when the other lane is sawed to eliminate the possibility of pavement blow up caused by expansion stresses being concentrated in only a portion of the width.

08.06.03.03 GENERAL REQUIREMENTS AT PATCHES

Figure 08-2 shows details of the five different types of patches that are used and the methods of constructing them. Possible locations of patches in the width of a pavement are shown in Figure 08-3. The recommended thicknesses of patches for small areas are given in Table 3. Tie bars, dowels and steel reinforcement may be left out of a small patch.

TABLE 3

**RECOMMENDED THICKNESSES OF PATCHES IN
PORTLAND CEMENT CONCRETE**

<u>DESIGN OF EXISTING PAVEMENT</u>	<u>DEPTH OF PATCH (D IN FIG. 2)</u>
A) Slab with thickened edges	1) On patches that involve unprotected *corners, D = 1.3 times thickness of original slab at center. 2) On all other patches, D = 1.2 times thickness of original slab at center.
B) Slab of uniform thickness with steel dowels at expansion joints.	1) On patches that involve unprotected *corners, D = 1.1 times thickness of original slab. 2) On all other patches, D = thickness of original slab.
C) Slab of uniform thickness, without steel dowels at expansion joints.	1) For all patches, D = thickness or original slab.

**An unprotected joint is a butt construction joint with neither dowels nor tongue-and-groove device to provide for transfer of load between adjacent lanes. A joint constructed with either dowels or a tongue-and-groove device for load transfer between adjacent lanes is a protected joint.*

When the full width of a slab is to be replaced for a length greater than 50 feet, the required thickness of the new slab is as follows: At an expansion joint the new thickness must be 1.3 times the thickness of the original slab at the center, except for a distance within 5 feet of an expansion joint, the new thickness must be 1.2 times the thickness of the original slab at the center. In the 5-foot length next to an expansion joint, the new slab must be tapered from the required thickness at the joint to the allowable thickness elsewhere.

In a large patch it is necessary to use dowels or tie bars having the same size and spacing as in the original work. When an entire single lane is to be patched, or when a patch is to be made at a joint between lanes (an inside edge patch), it may be possible to reuse the existing tie bars in the adjacent lane.

08.06.03.04 CENTER JOINT IN PATCH

Whenever a patch must extend over the full width of the pavement, a longitudinal center joint will be needed. Even if the original pavement lacked such a joint, one will be needed in the new slab because the patch usually will be placed one lane at a time. Before the first lane can be patched, enough of the second lane must be removed to make room for forms. Care must be taken to keep the new concrete in the first lane separated from the broken pavement, in order that the new concrete will not be damaged by traffic moving on the broken pavement. Refer to Figure 08-2 Type A. for details of this type patch.

If a single patch covers two lanes, a "weakened plane" type joint is needed between the lanes. This joint may be made at the time the concrete is placed by forming a dummy groove. Another way is to let the concrete harden and then to make a cut one fourth the depth with a concrete saw.

When an entire single lane is to be patched or an inside edge patch is to be made, the face of the joint that has not been disturbed must be thoroughly cleaned before the new concrete is placed against it. Tie bars projecting from the other lane may be left in place. The edge of the patch next to the center joint must be finished with an edging tool. The resulting groove will permit sealing of the joint after the patch is finished.

08.06.03.05 TRANSVERSE EXPANSION JOINT IN PATCH

If the patch does not extend over the full width of the pavement, any expansion joint in the original pavement must be replaced in its original position. Dowels are not needed because the thickness of patch recommended in Table 2 gives enough strength without them.

When the patch extends over the full width of the pavement, an expansion joint previously in the patched area may not be necessary. If an expansion joint is needed, it may be located at any place in the new patch that is more than 6 feet from an end of the patch. It does not have to be placed at the same location as the original joint.

Whenever an expansion joint is placed, an acceptable type and grade of joint material must be used. The joint must be sealed as described in Section 08.06.07.

08.06.03.06 CONTRACTION JOINTS IN PATCH

When the length of a full width patch is more than 25 feet, contraction joints must be placed so as to form slab lengths from 15 to 25 feet. When the width of the patch is less than the full width of the pavement, a contraction joint must be placed wherever one was located in the original work. The joint must be of the dummy groove type, and the depth of the groove must be equal to one fourth the depth of the patch. The groove may be made when the concrete is placed, or it may be cut later with a concrete saw. No dowels are needed, but each contraction joint must be sealed as described in Section 08.06.07.

08.06.03.07 PREPARING PAVEMENT FOR PATCH

Steps in preparing a concrete pavement for a patch are as follows:

- 1) The area to be patched must be marked. Sides of the patch must be either parallel or at right angles to the centerline of the road.
- 2) A cut 1-1/2 inches deep is made with a concrete saw along each side that is not bound by a joint. This cut will prevent "overhang" and uneven edges of the patch that might later cause spalls.
- 3) The old concrete is cut or broken into small pieces and removed. Usually the concrete cut must be broken with an air chisel, drill or pavement breaker.
- 4) Broken pieces of old concrete must be hauled away promptly. They will never be left along the shoulder or in the ditch.
- 5) If the subgrade beneath the old pavement is poorly drained, the necessary corrective action must be taken. Drains to carry water away may be needed. Any poor subgrade material must be removed and replaced with good material. If "pumping" has caused failure it may be advisable to place a granular base under the new patch. The thickness of this granular base should be at least 6 inches, and its width as much as 1 foot greater than the width of the pavement. It is poor practice to try to underpin the old concrete around the edge of the patch because it is too difficult to get a good job.
- 6) When the new concrete is placed, both the subgrade, whether new or old, and the edges of the old concrete must be damp but not wet.

08.06.03.08 CONCRETE FOR PATCH

The materials and methods of mixing the concrete for a patch must meet all the requirements of the Standard specifications. Before the patch is opened to traffic, the new concrete must have a breaking strength of 2000 pounds per square inch as shown by tests made on test cylinders. In order that vehicles may be allowed to ride on the patched area as soon as possible, it is usually advisable to use a mix that will give high early strength. This can be accomplished by using high early strength cement, a Seven (7) bag mix or an accelerator additive. Check with the District Maintenance Engineer or District Material Lab personnel for approved accelerator additive.

A dry, low slump (2"-3") concrete is best for patching. The use of soupy, high slump concrete will not be permitted. Care must be taken to make sure that the amount of water in the mix is not greater than the maximum allowed by the mix formula. When it is desired to shorten the time before a patch can be opened to traffic, high-early-strength cement is used instead of standard cement, or an approved type material is added to the concrete mix to hasten setting. If a quick setting material is added, the concrete hardens rapidly and it must be placed and finished quickly.

The use of air-entrained cement is required for all concrete pavement patching. Use of air-entrained cement does not add to the cost of the patch. Where feasible a temporary protective plate should be placed over a "green" patch.

08.06.03.09 MIXING AND PLACING CONCRETE

The procedure for mixing and placing concrete in a patch is as follows:

- 1) Concrete must be mixed in a machine for at least one minute. When a truck mixer or agitator is used to transport the concrete, the concrete shall be delivered to the site and discharge shall be complete within 1 1/2 hours after the addition of the cement to the aggregate..
- 2) After the concrete is placed it is vibrated or spaded to eliminate voids.
- 3) The concrete is then struck off by a screed which can be a long, straight timber or preferably a vibrating screed. It may be necessary to make several passes to obtain a uniform surface. Care should be exercised to avoid over finishing of the concrete to prevent excessive water brought to the surface.
- 4) When the concrete is in the plastic stage all uneven spots will be removed by floats. The surface should be left 1/8 inch high to account for shrinkage.
- 5) The final finish before curing is made by dragging wet burlap or a street broom over the surface perpendicular to the direction of traffic flow.
- 6) The completed patch shall be cured in accordance with one of the methods specified in the Portland Cement Concrete Pavement Section of the Standard Specifications.

08.06.03.10 EQUIPMENT

A list of equipment needed by a patching crew includes the following:

- 1) Portable concrete saw.
- 2) Air compressor.
- 3) Pavement breakers to be used with the air compressor, or pavement breaker with drop hammer (mobile hammer), or hoeram.
- 4) Supply of chisels, bits, shovels and finishing tools.
- 5) Barricades and warning signs.
- 6) Sufficient trucks for disposal of broken concrete, transporting equipment and supplies.

- 7) End-loader, gradall or backhoe for loading broken concrete onto the truck.
- 9) Suitable screed.
- 10) Vibrator

08.06.04 REPAIR OF JOINT SPALLS

The selection of a spall repair method will depend on its cause and the extent of damage. Minor problems may be solved by cleaning and resealing of the joint. If the spalling is extensive the section of pavement should be removed and replaced as previously described.

08.06.05 REPAIR OF SCALED AREA

08.06.05.01 CORRECTION OF LIMITED SCALING

The repair of portland cement concrete pavement where a limited amount of scaling has occurred should be accomplished as follows:

- 1) Define and mark limits of area to be repaired (patches should be square or rectangular in shape).
- 2) Make vertical cut along all edges of the patch with a concrete saw to a depth of at least 1 1/2 inches.
- 3) Remove old concrete to a uniform depth of at least 2 inches using hand, air, or hydraulic tool. If reinforcing is encountered, it should be thoroughly cleaned and repaired or replaced as necessary.
- 4) Dampen all surfaces of the hole, fill with portland cement concrete, and vibrate using hand or mechanical methods. Screed to grade and apply suitable finish to complete the repair.

If approved by the District Maintenance Engineer, bituminous concrete may be used as a substitute for portland cement concrete when repairing scaled areas of portland cement concrete pavement.

08.06.05.02 CORRECTION OF EXTENSIVE SCALING

The repair of portland cement concrete, where extensive scaling has occurred, should be accomplished by overlaying the entire roadway with a bituminous concrete surfacing course as described in Section 08.03 of this Manual.

08.06.06 REPAIR OF SETTLED CONCRETE PAVEMENT

Settlements of portland cement concrete pavements are corrected by complete

removal and replacement of the settled slab or by overlaying of the slab(s) with bituminous concrete.

When conditions warrant complete slab replacement, the repairs should be accomplished as outlined in Section 08.06.03.03 of this Manual.

Correction of settled areas using a bituminous concrete overlay should be accomplished as outlined in Section 08.03.03.06 of this Manual.

08.06.07 RESEALING JOINTS AND CRACKS IN CONCRETE PAVEMENT

08.06.07.01 PURPOSES OF TREATMENT

The purposes of resealing joints and cracks are to prevent the seepage of surface water through openings in the pavement, to keep foreign solids out of these openings, and to preserve the original joint filler which tends to deteriorate if it is not protected. Properly filled cracks and joints will help prevent surface water from entering the base and subgrade, thus reducing the possibility of damage caused by pumping or frost action. Foreign materials can enter unfilled joints and cracks causing spalling when expansion of the pavement occurs.

08.06.07.02 DESIRABLE WEATHER CONDITIONS

Cool, dry weather is ideal for resealing joints and cracks. Before a joint is filled, all free moisture must be removed. When the weather is cool the pavement will be contracted so that the joints and cracks are open and can be cleaned and sealed easier. The best time of the year to plan the sealing of joints and cracks is early fall.

08.06.07.03 PROCEDURE

Before joints and cracks in a concrete pavement are resealed, it is necessary to remove old sealing material and foreign matter. Only cracks that are at least 1/8 inch wide will be cleaned and resealed. The operations to be performed in the resealing process are as follows:

- 1) Foreign material is removed by use of joint routers. A hand hook similar to the one shown in Figure 08-4, may be useful in some cases.
- 2) The bottom of the joint or crack is carefully brushed with a hand broom, and power driven wire brushes are used to clean the walls of the joint or crack and the edges of the pavement.
- 3) Compressed air is applied to blow out the joint or crack and to blow off the adjacent pavement.
- 4) The sealing compound is poured into the joint or crack. Any of several approved types of equipment may be used for heating the material and filling the joint or crack. When a joint or crack is filled properly, the top of

the sealing compound will be about 1/8 inch lower than the pavement surface, and no material will be spilled on the adjacent pavement surface. If it becomes necessary to seal joints and cracks during hot weather, the sealing compound will be left flush with the pavement surface. If a cover is needed to keep traffic from tracking freshly poured material onto the pavement, narrow strips of paper or sawdust may be used. *It is not permissible to use aggregate of any kind.*

08.07 ASPHALTIC PATCHING MATERIALS

08.07.01 TYPES OF PATCHING MATERIALS

Asphaltic patching materials have a very important function in the maintenance of paved surfaces. These materials are classified as hot-mix or cold-mix patching materials. This classification is based on the temperature of the material when it is used for patching. Capabilities and limitations of each class must be understood to insure proper selection and use.

As previously stated, material that is used to patch a paved surface permanently, should normally be of the same type as the material used in constructing the original surface. Ordinarily, a hot-laid bituminous concrete surface will be patched with a hot-mix material; a road-mixed mat will be patched with a cold-mix material, and portland cement concrete will be patched with cement concrete. It may sometimes be impractical to use the preferred type of patching material. In this situation, the Maintenance Engineer should select the type patching material to be used.

08.07.02 HOT-MIX PATCHING MATERIALS

The disadvantage of a hot-mix patching material is that the material must be used soon after it has been prepared. Since a material of this type cannot be stockpiled for later use, care must be taken to make sure that only the amount needed to do a specific job is obtained. The main advantage in using a hot-mix material is that it will provide a permanent patch when properly installed in a bituminous concrete or portland cement concrete pavement.

Hot-mix patching material is usually prepared in a commercial paving plant. The material will remain workable for only a limited time. Before a load of hot-mix patching material is delivered to the job site, enough patches must be prepared to use the entire load.

There are several types of hot mix available. In a course-graded mix, the aggregate consists of a combination of crushed course aggregate, crushed fine aggregate, and sand. In a fine-graded mix, all the aggregate consists of sand and crushed fine aggregate. A course-graded mix is preferred for patching deep holes or depressions. A fine-graded mix is most useful for a thin patch.

The handling and placing of hot mix in patching operations has been described in Section 07.02.03.04, which deals with the repair of potholes in a bituminous concrete surface course.

08.07.03 COLD-MIX PATCHING MATERIALS

08.07.03.01 TYPES OF COLD MIXTURES

A cold-mix patching material is used frequently for a temporary patch in a pavement of bituminous concrete or portland cement concrete. Such a material is also used for a permanent patch on a road paved with a surface treatment. Some cold-mix patching materials are dense-graded and some are open-graded. The dense-graded mix contains both coarse and fine aggregate particles. The open-graded mix contains little or no fine material.

Different types of liquid asphaltic are used for making cold mix. The type and grade used will depend on the gradation of the aggregate, on how soon the mixture will be used after it is mixed, and on the method used for mixing the materials. Some of the different types of liquid asphalt used in the production of cold mix are shown in Table 4.

TABLE 4

LIQUID ASPHALT FOR COLD MIX

Type of Bituminous Material	Temperature Range at Time of Mixing (Degrees F)	Aggregate Gradation	Method of Mixing
MX-2 emulsion	70 – 160	Open graded	Plant or blade mix
SS-1 & SS-1h emulsion	70 – 160	Dense graded	Plant or blade mix
HFMS-2 emulsion	70 – 160	Open graded	Plant or blade mix
CMS-2 emulsion	70 – 160	Open graded	Plant or blade mix
MC-250 cut-back	150 – 200	Dense graded	Plant or blade mix

When the bituminous material in a cold-mix patching mixture is a medium curing or slow curing cut-back or emulsion, the mixture can be stockpiled for a long period of time and can be used as needed. Such a mixture has a big advantage over a hot-mix material in this respect. A cold mixture made with a rapid-curing asphalt emulsion must be used soon after it has been prepared. A popular way of making a large quantity of a cold patching mixture is by using the so-called "blade-mix" method. In this method, the aggregate and the bituminous material are mixed by blading the materials back and forth with a grader.

When cold-mix material is stored in stockpiles, each pile must be built up and maintained in the shape of a tent. This shape permits the material to shed rainwater more rapidly. If patching material is to be piled on an unpaved surface, the location must first be graded so that it will drain, and must then be rolled and treated with a soil sterilant.

08.07.03.02 GENERAL REQUIREMENTS

Before aggregates are used in a patching mixture, samples of each material must be sent to the Materials Control, Soils and Testing Division. There a check will be made to be sure that the materials are suitable for the intended use. The aggregates must be clean and properly graded in size. The Materials Control, Soils and Testing Division will also recommend the kind and amount of bituminous material which will be best suited for the patching mix wanted.

The usual and preferred maximum size particles of aggregate for a patching mix are 1/2 inch. Such mix "feathers" out better, provides a smoother driving surface, and is less likely to "ravel" out in cold or rainy weather or during spring thaw periods. At the time a cold patching mix is prepared, the amount of moisture in the aggregate (sand, stone or gravel) must be less than 2 percent unless an emulsion is being used or unless a "no-strip" additive is included in other bituminous materials. An excessive amount of moisture is no problem when the mix is made in a paving plant equipped with a drier or in a pug-mill mixer. Moisture can be a problem when the mix is made in a small mechanical mixer such as a concrete mixer or when the blade mix method is used. In either of these cases, mixing of the aggregate and the bituminous material must be delayed while the damp aggregate is turned over again and again until the sun and the air have reduced the moisture content to 2 percent or less.

When the blade mix method is used, it is necessary to perform the mixing operation on a hard, smooth mixing surface. An abandoned section of old surfaced road makes a good mixing surface.

08.07.03.03 BLADE MIXING OF DENSE-GRADED MIX

The aggregates used for a dense-graded mix will depend on the locality. In general, all aggregate must be clean and well graded. The maximum permissible amount of material passing the No. 200 sieve is 7 percent, since too much fine material produces a stiff mix that cannot be handled easily. Such a mix also may lack stability and may be pushed out of shape under traffic.

The required quantity of bituminous material will depend on the type and gradation of the aggregate. The finer the aggregate or the denser the mix, the greater the quantity of bituminous material needed to coat the increased surface area of the aggregate particles in a given volume.

When a mix has been prepared, the correct amount of bituminous material for the gradation used may be judged by considering the color of the mix. The correct color is dull black showing that all particles are coated and not shiny black. When a mixture containing the correct amount of bituminous material is thrown into a pile, it

will creep (the particles will slowly roll over one another), and will not slump into a solid mass. The tendency in blade mixing is to use too much bituminous material, in order to get a coating on the aggregate with as much bituminous material and as little work as possible.

Mixing and aeration must be continued until the moisture and other volatiles are evaporated to the proper extent. If the mix is to be used immediately, it must be much stiffer than if it is to be stockpiled.

08.07.03.04 BLADE MIXING OF OPEN-GRADED MIX

The gradation of the aggregates in an open-graded mixture is usually within the following limits:

<u>SIZE</u>	<u>PERCENT PASSING</u>
1/2 in	100
No. 4	20 to 40
No. 8	0 to 10

This gradation falls within the limits for AASHTO No. 8 aggregate found in the Standard Specifications.

The bituminous material used for this type may be asphalt emulsion of grade MS-2 or SS-1. The amount of bituminous material, by weight, of the total mix should be about 5 percent. Any of these mixes will set quite rapidly, and such a mix cannot be stockpiled for long. The surface of patches using this mix must be protected with a seal coat.

08.07.03.05 PLANT MIXING OF DENSE-GRADED MIX

When a plant mixed dense-graded mixture is to be stockpiled, the bituminous material most commonly used is MC-250. The mixture is prepared in a conventional hot plant mixer or a pug-mill mixer. The temperature is held at about 160°F, and must always be kept below 200°F. Although there may be a little crusting on the outside of a stockpile, the material at the inside will stay workable because it retains a certain amount of volatiles and moisture.

When the aggregate is heated to a temperature between 100°F and 200°F, the moisture content is usually reduced to less than 2 percent. If coating is difficult, a small amount of lime (1 percent) will help to get good coating and to prevent stripping.

A typical aggregate gradation for a successful dense-graded mix is as follows:

<u>SIZE</u>	<u>PERCENT PASSING</u>
3/8 in.	100
No. 4	80 to 100
No. 10	60 to 80
No. 40	10 to 30
No. 80	5 to 15
No. 200	0 to 7

The required amount of bituminous material is 4.5 - 5.5 percent, by weight.

08.08 SCHEDULING OF ROUTINE MAINTENANCE OF PAVED SURFACES

08.08.01 SPRING OPERATIONS

The maintenance operations that can be performed on paved surfaces during the spring are as follows:

- 1) Routine patching of all potholes as soon as the roads become clear of ice and snow.
- 2) Detailed inspection of all paved surfaces for estimating the amount of patching required.
- 3) Preparation of program for major patching and detailed inspection of each location to determine the type, quantities and costs of the materials needed.
- 4) Requisition materials needed for the repair and maintenance of surfaces.
- 5) Remove temporary patches and replace with permanent ones.
- 6) Routine inspection of all surfaces continued.
- 7) After May 1, start of resurfacing or planned roads.
- 8) Start of planned major repairs.

08.08.02 SUMMER OPERATIONS

During the summer, the following maintenance operations are performed:

- 1) Continue routine inspections of paved surfaces
- 2) Continue removal of temporary patches and carrying out permanent repairs with proper material.
- 3) Continue work on planned major repairs.

- 4) Continue resurfacing and work on other surface improvements.
- 5) Inspect all cracks and joints and prepare program for sealing operations.

08.08.03 FALL OPERATIONS

Fall maintenance work includes the following operations:

- 1) Complete all resurfacing before October 1.
- 2) Complete all planned major repairs.
- 3) Complete permanent-type patching.
- 4) Continue routine inspections.
- 5) Reseal all cracks and joints that are open.
- 6) Start temporary repairs that are required.

08.08.04 WINTER OPERATIONS

Only a few maintenance operations may be performed in the winter. They are as follows:

- 1) Continue routine inspection of paved surfaces.
- 2) Make temporary repairs as soon as a failure is noted.
- 3) Prepare plan for spring and summer maintenance.

FOOTNOTE

As more fully set forth in Section 01.01.01, nothing in this manual is intended to create a legal or moral duty and has been created for internal guidance only.