PDHonline Course C767 (3 PDH)

Asphalt Maintenance and Repair

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2020

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UFC 3-270-01
15 March 2001

UNIFIED FACILITIES CRITERIA (UFC)

ASPHALT MAINTENANCE AND REPAIR

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ASPHALT MAINTENANCE AND REPAIR

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	**Date**	**Location**
1	16 May 2006	Revised Foreword

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FOREWORD

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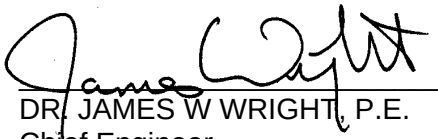

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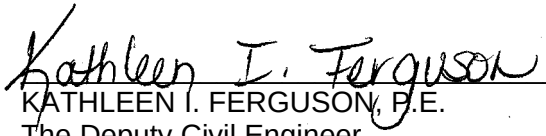

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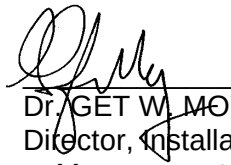

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Acknowledgment

This handbook was prepared by Mr. Carroll J. Smith, U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, and is an update of an earlier version prepared by SMSgt Michael L. Sonnenberg, U.S. Air Force Civil Engineer Support Agency (AFCESA/CESC), Tyndall Air Force Base, Florida. Funding for this project was provided by AFCESA/CESC, and it was monitored by Mr. Richard Smith, AFCESA/CESC.

CHAPTER 1

INTRODUCTION

1.1. Scope. This handbook contains information on materials, equipment, and procedures for repairing asphalt cement concrete (ACC) pavements. Problem areas are also presented for the types of maintenance and repair of ACC pavements. Additional information can be found in the references listed in the following paragraph. **AF Records Disposition**. Ensure that all records created by this handbook are maintained and disposed of IAW AFMAN 37-139, "Records Disposition Schedule."

1.2. References.

1.2.1. Departments of the Army, Navy, and Air Force. (1995). "Maintenance and Repair of Surface Areas," TM 5-624/NAVFAC MO-102/AFJM 32-1040, Washington, DC.

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CHAPTER 2

PURPOSE AND TYPES OF MAINTENANCE AND REPAIR

2.1. Purpose. The purpose of maintenace and repair (M&R) of asphalt pavements is to extend the useful life of the pavement, maintain a smooth riding surface, and prevent water from entering the underlying soil. Limited manpower and resources have increased the importance of M&R to the life of a pavement. To keep a pavement in the best possible condition, it is important to use an effective pavement management and inspection system. As pavements are repaired, it is extremely important to analyze and repair the "true cause" of the pavement distress and not just repair the distress. The intended function of pavements depends on proper and timely maintenance and repair. To implement an effective pavement management and inspection program, TM 5-826/AFR 93-5 and TM 5-623 should be used. These technical manuals describe all ACC pavement distresses and severity levels.

2.2. Types of Maintenance and Repair. There are numerous types of M&R methods for ACC pavements which include crack sealing (presented in UFC 3-270-02, "Asphalt Crack Repair"), sealcoats, and overlays. This handbook presents the basic M&R procedures along with relevant distresses. The handbook will not present overlays or new construction. M&R procedures presented in this handbook include the following:

2.2.1. Full-depth and partial-depth patch. A full-depth patch is used to repair distresses such as alligator cracking, corrugation, depression, oil spillage, rutting, swelling, edge cracking, and bumps and sags, and replacing patches. A partial-depth patch is used to maintain/repair distresses of low and medium severity, such as alligator cracking, corrugation, depression, rutting, shoving, slippage cracking, swelling, and replacing patches.

2.2.2. Sprayed asphalt surface treatments. Surface treatments include prime coats, tack coats, fog seals, and rejuvenators. A prime coat is applied to a nonbituminous base course during construction and prior to placement of a bituminous pavement. A tack coat is applied to an old pavement surface prior to the surface being overlaid with a new ACC pavement. Fog seals and rejuvenators are repair alternatives used for repairing small cracks (less than 1/4 inch (6 millimeters)) or pavements with weathered, oxidized, or brittle surfaces.

(NOTE: Due to possible foreign object damage (FOD) problems, the major command (MAJCOM) or Transportation Systems Center (TSMCX) engineer must be consulted prior to using a surface seal or rejuvenators as repair options.)

2.2.3. Sprayed asphalt with surface aggregate. Surface aggregate treatments consist of sprayed asphalt applications followed by one or more layers of aggregate. The two types of treatments are single bituminous surface treatment (SBST) and double bituminous surface treatment (DBST). These two treatments are used to repair areas containing small cracks (1/4 inch (6 millimeters) or less), weathering/raveling, polished aggregate, block cracking, and low-severity alligator cracking (usually a temporary repair). A variational treatment used to repair bleeding consists of applying hot sand to the distress, followed by rolling.

2.2.4. Asphalt slurry seal. A slurry seal consists of a mixture of aggregate and asphalt emulsion. Slurry seals are used to repair the same distresses as discussed in Paragraph 2.2.3. (sprayed asphalt with surface aggregate).

2.2.5. Patching (filling ruts and depressions). A patch can be used to repair rutting and depressions by filling the distresses with asphalt.

2.2.6. Porous friction surfaces. Special repair procedures specifically applicable to these porous friction surfaces are presented and discussed in Chapter 8.

2.3. Repair Options. There are usually several different options for repairing a distress. The "true cause" of a distress should be analyzed and then a repair method should be selected to best resolve the distress cause. The M&R procedures in Paragraph 2.2. are presented in the following chapters with logical and sequential steps to accomplish the tasks.

2.4. Importance of Weather. The following guidance should be followed to successfully repair asphalt pavement during appropriate weather conditions.

2.4.1. Preferably, patching or resurfacing work should be performed during warm, 50 degrees Fahrenheit (10 degrees Celsius) and above, and dry weather. When hot or warm asphalt mixtures are placed on cold pavements, they may cool quickly and cause adequate compaction to be difficult. Moreover, asphalt and asphalt mixtures usually do not bond well to damp surfaces.

2.4.2. Mixtures containing emulsified or cutback asphalt are slow curing when the humidity is high. Low temperatures also slow evaporation during curing.

2.4.3. Seal coats and other surface treatments can be affected by moisture during the first few hours after placement. Rainfall prior to the time the liquid asphalt solidifies can result in the leaching away or segregation of the asphalt from the aggregate. This could result in the loss of some or all of the applied surface treatment.

2.4.4. This does not mean that repairs cannot be performed during cold or damp weather. Rather, they require much greater care when made during such weather conditions, and the repairs are much less likely to be satisfactory. It is better, however, when the safety and comfort of the traveling public are concerned, to make the repairs even though they may be only temporary. Also, a delay in repairs may allow small surface defects to progress into major failures.

CHAPTER 3

FULL-DEPTH AND PARTIAL-DEPTH PATCHES

3.1. Introduction. Various distresses (see Paragraph 2.2.) can be repaired by using full-depth or partial-depth patches. A graphic presentation for the emplacement of a full-depth patch and utility cut repair on an ACC pavement is shown in Figures 3.1. and 3.2., respectively. Full-depth repairs involve removal of the complete pavement down to the subgrade or to an intermediate base or subbase layer that is intact. Partial-depth repairs usually involve removing the failed bituminous surface excluding the base course and replacing the surface layer with hot-asphalt plant mix.

3.2. Procedural Steps (Full-Depth Patch). The following steps should be conducted for the placement of a full-depth patch.

3.2.1. Mark the repair area. A string line or straight edge should be used to mark straight lines around the repair area. The lines should be marked with spray paint so they are easily visible when sawing the pavement. Repair areas should be marked to form a square or rectangle with at least 12 inches (300 millimeters) beyond the distressed area (Figure 3.3.).

3.2.2. Saw the pavement. A concrete saw equipped with a diamond-tip or abrasive blade (Figures 3.4. and 3.5.) is used to saw the pavement. Saw cuts shall overlap so that a vertical and square corner is formed (Figure 3.6.). Since diamond-tip blades usually require water, the repair area should be completely dry before it is repaired. However, there are some types of diamond-tip blades designed to dry cut asphalt pavements. The abrasive saw blade has advantages of lower cost and does not require water when sawing. A disadvantage is that the abrasive blade tends to wear quickly. One should make sure that the saw blade is the correct diameter to allow cutting to the full depth of the pavement. Make sure that the saw blade is rated

for the revolutions per minute (RPM) of the saw; otherwise, the blade could shatter during sawing if the blade does not have the correct RPM rating.

3.2.3. Jackhammer and remove defective material. An asphalt bit shall be used in the jackhammer. The jackhammer should be operated from the middle of the repair area and move toward the edges. (Do not rock the hammer near the edge — this will destroy the vertical face.) If a saw is not available, the perimenter of the patch can be cut with the jackhammer. Since this method forms rough edges, it is not recommended. It is important that the cuts around the distress should be as vertical as possible. After jackhammering, remove and discard the loose material.

3.2.4. Remove, replace, and compact the base. When performing a full-depth patch, the base should be visually inspected to ensure that the condition of the material is adequate. All inadequate base, subbase, or subgrade materials should be removed until a good, dry, and dense material is located. The poor-quality material shall be replaced with a good-quality, well-graded base material. If subgrade material is removed, crushed stone or other suitable base material may be used to backfill to the top of the subgrade. New materials shall be placed in 2- to 3-inch (50- to 75-millimeter) lifts with each lift compacted to the required density. When removing the defective pavement, the base material is always disturbed. Therefore, the base material should always be recompacted prior to performing the next step.

3.2.5. Apply tack coat (and prime coat if used). A prime coat can be used to spray the sides and bottom of the hole to be patched with hot-asphalt plant mix. Recommended prime coat materials are RC-70, MC-30, MC-70, or SC-70 cutback; an SS-1, SS-1h, CSS-1, or CSS-1h emulsion. The application rate is 0.10 to 0.25 gallons per square yard (0.45 to 1.13 liters per square meter). Too heavy an application could cause bleeding. Prime coats must be allowed time to penetrate the base material. They are usually absorbed in 2 to 3 hours and should be fully cured in up to

48 hours. If a prime coat is not used, a thin tack coat should be applied to the edges and bottom of the patch. This coating provides a good bond between the old and new materials. The patch area edges shall be clean, dry, and free of any dust to ensure that the tack coat will bond to the edges. Recommended tack coat materials include the use of cutback grades RC-70, RC-250; or emulsion grades RS-1, MS-1, SS-1, SS-1h, CSS-1, CSS-1h; or asphalt cement grades AC-2.5, AC-5, AC-10, AR-1000, AR-2000, or AR-4000. The tack coat application rate is 0.05 to 0.10 gallons per square yard (0.23 to 0.45 liters per square meter). A handspray wand should be used to apply the tack coat (Figure 3.7.). If a wand is not available, a stiff brush can be used. In order to prevent bleeding, too much tack should not be applied to the patch areas. (Too little tack is better than too much.)

3.2.6. Place the patch material. A good-quality, hot-asphalt plant mix material should be used to fill the patch. The material should be placed and compacted in 2- to 3-inch (50- to 75-millimeter) lifts. In order for the patch to be level with the surrounding pavement, the patch area should be overfilled to allow for compaction (Figure 3.8.). (A good rule of thumb for overfilling is about 40 percent — depending on the mix; i.e., 3 inches (50 millimeters) compacted = 4 1/4 inches (106 millimeters) uncompacted.) Patch material should not be overworked with a lute, shovel, or rake. Overworking, especially at the surface, causes segregation of the mix.

3.2.7. Compact the patch area. Using an appropriate method, the mix shall be compacted to the proper level. The size of the patch will determine which type compactor to use. For a very small patch area or areas, a hand tamper can be used. Larger areas require the use of a vibratory plate tamper or a steel-wheel roller (Figures 3.9. and 3.10.). To ensure the required compaction, the proper equipment should be used and determined by the size of the patch. The edges of the patch should always be compacted first, followed by compacting the remaining patch area in the direction of traffic. Previous compaction lanes should be overlapped by about 6 inches (150 millimeters) across the patch area (Figure 3.11.). When the patch is competely compacted,

it should be level or no higher than 1/8 inch (3 millimeters) above the surrounding patch surface (Figure 3.12.).

3.2.8. Seal the patch. After completing the patch, the final step is to seal the edges with an appropriate joint sealant material (Figure 3.13.). This will give added protection from water infiltration. The edge seal should be no more than 2 inches (50 millimeters) wide.

3.3. Procedural Steps (Partial-Depth Patch). The following steps should be conducted for the placement of a partial-depth patch.

3.3.1. Mark the repair area. This is the same as for a full-depth patch (Paragraph 3.2.1.).

3.3.2. Saw the pavement. A concrete saw equipped with a diamond-tip or abrasive blade (Figures 3.4. and 3.5.) is used to saw the pavement. Saw cuts shall overlap so that a vertical and square corner is formed (Figure 3.6.). Since diamond-tip blades usually require water, the repair area should be completely dry before it is repaired. However, there are some types of diamond-tip blades designed to dry cut asphalt pavements. The abrasive saw blade has advantages of lower cost and does not require water when sawing. A disadvantage is that the abrasive blade tends to wear quickly. The depth of cut should be controlled to allow cutting to the depth required for the repair. Make sure that the saw blade is rated for the RPM of the saw; otherwise, the blade could shatter during sawing if the blade does not have the correct RPM rating.

3.3.3. Jackhammer and remove defective material. This is the same as for a full-depth patch (Paragraph 3.2.3.).

3.3.4. Apply tack coat. A thin tack coat should be applied to the edges and bottom of the patch. This coating provides a good bond between the old and new materials. The patch area edges shall be clean, dry, and free of any dust to ensure that the tack coat will bond to the edges.

Recommended tack coat materials include the use of cutback grades RC-70, RC-250; or emulsion grades RS-1, MS-1, SS-1, SS-1h, CSS-1, CSS-1h; or asphalt cement grades AC-2.5, AC-5, AC-10, AR-1000, AR-2000, or AR-4000. The tack coat application rate is 0.05 to 0.10 gallons per square yard (0.23 to 0.45 liters per square meter). A handspray wand should be used to apply the tack coat (Figure 3.7.). If a wand is not available, a stiff brush can be used. In order to prevent bleeding, too much tack should not be applied to the patch areas. (Too little tack is better than too much.)

3.3.5. Place the patch material. This is the same as for full-depth patch (Paragraph 3.2.6.).

3.3.6. Compact the patch area. This is the same as for full-depth patch (Paragraph 3.2.7.).

3.3.7. Seal the patch. This is the same as for full-depth patch (Paragraph 3.2.8.).

3.4. Problem Areas. The major problem in constructing a successful patch is compaction of both the base and patch material. Thin lifts (less than 3 inches (75 millimeters)) for compaction will work best for each material. Too much prime or tack coat is also a problem. If a spray wand is used, a test on an adjacent area should be performed to ensure the correct amount of prime or tack coat is being applied. If not, spray nozzles, settings, or operational procedures should be changed to assure the correct amount of coatings.

(NOTE: If RC-70 or other cutbacks are used as a prime or tack coat, their use must comply with local environmental regulations.)

Figure 3.1. Steps for full-depth patch

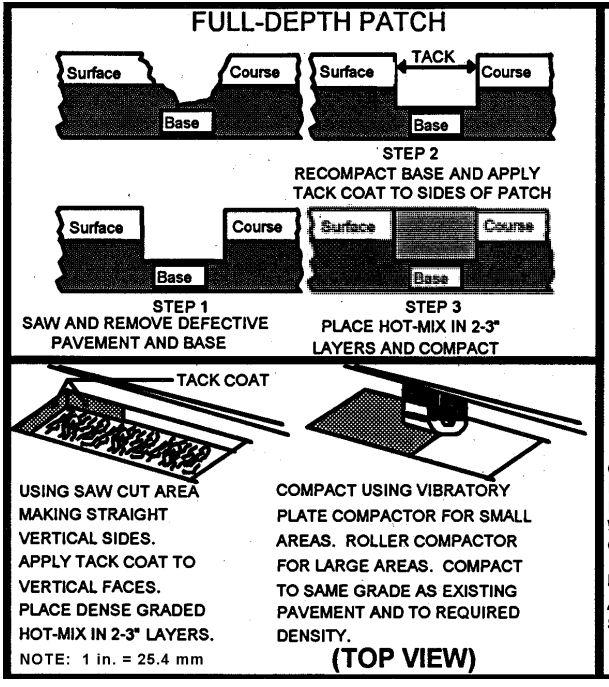


Figure 3.2. Steps for utility cut repair

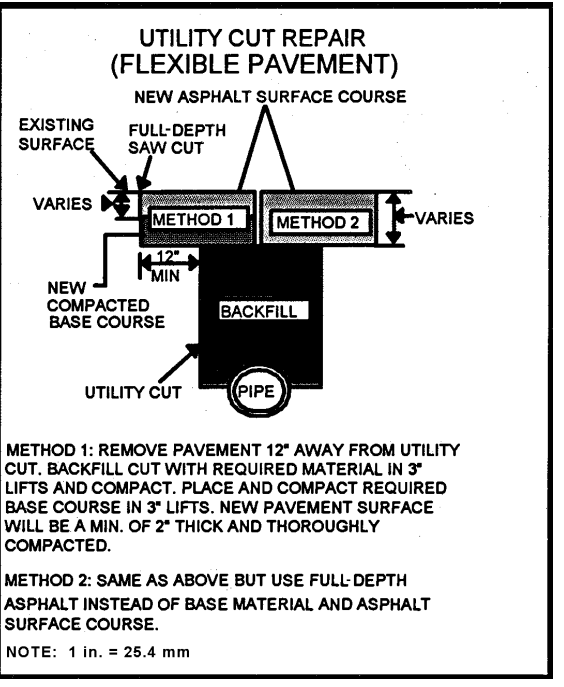


Figure 3.3. Saw cutting marked repair area

Figure 3.4. Diamond-tip blade

Figure 3.5. Abrasive blade

Picture 3.6. Overlapping saw cuts to form vertical and square corner

Figure 3.7. Applying tack coat with spray wand

Figure 3.8. Overfilled patch area

Figure 3.9. Vibratory plate tamper

Figure 3.10. Steel-wheel roller

Figure 3.11. Overlapping compaction lanes

Figure 3.12. Level patch surface

Figure 3.13. Sealing edges of the patch

CHAPTER 4

SPRAYED ASPHALT SURFACE TREATMENTS

4.1. Prime Coat. A prime coat is a spray application of bituminous material applied to the surface of a base course which is to be covered with a pavement layer. The purpose is to waterproof and prevent raveling of the base during construction and to form a dense base to which a bituminous pavement will adhere. Materials that can be used for prime coats are listed as follows: RC-70, MC-30, MC-70, or SC-70 cutback; SS-1, SS-1h, CSS-1, or CSS-1h emulsion.

4.2. Procedural Steps (Prime Coat). The following steps should be conducted to apply a prime coat.

4.2.1. Prepare the surface. The surface shall be free of all loose material such as dirt, clay, dust, or any other undesirable material. A light brooming should be used to remove these undesirable materials. If the base is excessively dry, it should be lightly sprinkled with water.

4.2.2. Apply the prime. If the area to be primed is large, a distributor should be used. Prime coat applications on smaller areas can be sprayed with a handspray wand. Prime coat application rates are 0.10 to 0.25 gallons per square yard (0.45 to 1.13 liters per square meter). The entire area shall be coated.

4.2.3. Allow prime to cure. Prime coats shall be allowed to cure for as long as necessary. Curing time can be up to 48 hours. If there is excess prime, it should be blotted with fine sand or mineral dust.

4.3. Problem Areas (Prime Coat). A major problem is overpriming. Application rates should be tested prior to priming. Proper nozzles and settings on the distributor spray bar or handwand should be checked. Nozzles should be checked to ensure they are not plugged and nozzles

should be set at the proper angle (Figure 4.1.). The use of RC-70 or other cutbacks as a prime coat must comply with local environmental regulations.

4.4. Tack Coat. The tack coat is applied to an existing pavement surface before it is overlaid with a new ACC pavement. The tack provides a bond between the old and new pavement. Materials which can be used for tack coats are listed as follows: cutback grades RC-70, RC-250; emulsion grades RS-1, MS-1, SS-1, SS-1h, CSS-1, CSS-1h; or asphalt cement grades AC-2.5, AC-5, AC-10, AR-1000, AR-2000, or AR-4000.

4.5. Procedural Steps (Tack Coat). The following steps should be conducted to apply a tack coat.

4.5.1. Prepare the surface. The surface must be clean and dry; and free of dust, loose dirt, and all other objectionable debris. The surface around and inside the patch should be cleaned with brooms, air, and water.

4.5.2. Apply the tack. Tack coats for large areas require the use of a distributor. A handwand can be used for patches and hard-to-apply areas. If a wand is not available, the tack can be applied to patch edges with a stiff brush. The tack coat should be applied in an even and uniform coat over the entire area. If the surface should appear that there is not enough tack — it should be remembered that too little tack is better than too much. No more tack material should be applied than can be covered by the end of a working day. Application rates for tack coats range from 0.05 to 0.15 gallons per square yard (0.23 to 0.68 liters per square meter).

4.5.3. Allow tack to cure. The tack coat shall be allowed to cure before placing the overlay or patch material. Cure times will vary according to the type tack material used.

4.6. Problem Areas (Tack Coat). An over application of tack will cause bleeding and slippage; therefore, the proper application rate should be ensured. Application rates should be tested prior

to spraying the tack material. Proper nozzles and settings on the distributor spray bar or handwand should be checked. Nozzles should be checked to ensure they are not plugged and nozzles should be adjusted to the proper angle and height. Areas for tack coating shall be clean and dry. The use of RC-70 or other cutbacks as a tack coat must comply with local environmental regulations.

4.7. Fog Seals and Rejuvenators. A fog seal is a spray application of a diluted asphalt or tar emulsion. Fog seals are used on sound plant mixed surfaces to seal a weathered, oxidized pavement or on a pavement containing numerous small cracks. Emulsions used for fog seals are SS-1, SS-1h, CSS-1, or CSS-1h. Rejuvenators are commercially available products which are used to restore oxidized pavement surfaces. They should not be used on pavements that exhibit raveling (unless raveling is very minor) or that have cracking (unless cracking is a very minor hairline). Rejuvenators can cause restored pavement surfaces to be slippery for up to a year; therefore, extreme care should be taken in choosing areas and application rates. Since there are numerous commercially available products, a list of rejuvenators will not be presented.

4.8. Procedural Steps (Fog Seals and Rejuvenators). The following steps should be conducted for the application of fog seals and rejuvenators.

4.8.1. Prepare the surface. The surface shall be thoroughly cleaned prior to application. This is discussed in Paragraphs 4.2.1. and 4.5.1. Other distresses should be repaired before application.

4.8.2. Determine proper application rate. The application rate will vary according to the quantity of material the pavement absorbs. Therefore, field test sections should be sprayed with different application rates to determine the best rate. The rate should be adjusted so that the treated surface is not slick, unstable, and does not contain excess material after 12 to 24 hours curing.

4.8.3. Dilute the material. The material can be used undiluted, but it is usually diluted. Dilution rates can be as high as 1 part emulsion to 10 parts water, with an average of 1 part emulsion to 4 parts water. Manufacturer's dilution directions for rejuvenators should be followed.

4.8.4. Apply the material. A calibrated asphalt distributor shall be used for material application (Figure 4.2.). The calibration of the distributor is very important. The spray bar nozzles should be set at the proper angle and height. Nozzles shall be the proper size and all nozzles should be the same size for proper material application. Make sure that the nozzles are not plugged before asphalt material is applied. To avoid slick surfaces, the asphalt material should be applied in multiple applications over the entire area.

4.8.5. Cure time. The fog seal should be allowed to fully cure before traffic is allowed on the treated pavement. Cure time is usually 12 to 24 hours.

4.9. Problem Areas (Fog Seals and Rejuvenators). The distributor calibration and spray bar can cause possible problems during material application; therefore, the distributor should be calibrated, adjusted, and cleaned. The MAJCOM or TSMCX pavement engineer should be contacted before a rejuvenator is used. Generally, fog seals are not allowed for airfield treatments because they tend to reduce skid resistance; however, the MAJCOM or TSMCX should be contacted. A major problem is over application of material; therefore, proper application and dilution rates should be followed. Preliminary tests should be conducted to determine the proper application and dilution rate.

Figure 4.1. Spray bar and nozzle settings

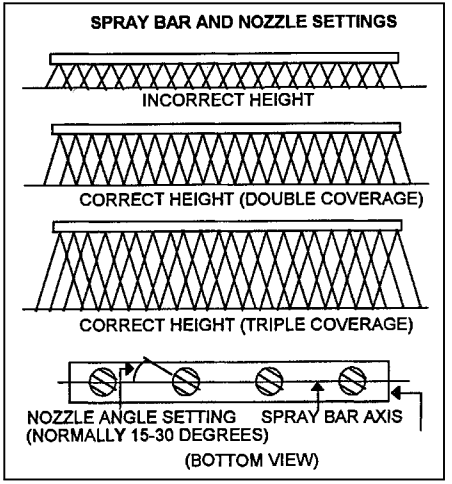


Figure 4.2. Asphalt distributor

CHAPTER 5

SPRAYED ASPHALT WITH SURFACE AGGREGATE

5.1. Introduction. Single and double bituminous surface treatments (SBST and DBST, respectively) consist of sprayed asphalt applications followed immediately by one or more layers of aggregate. These treatments are used to retard deterioration of raveling, improve skid resistance, seal small cracks, and waterproof the surface. They are usually used on light-traffic roads and overruns. Another type SBST, sandseal, is also presented. Also, a variational procedure of SBST to repair bleeding is presented and consists of applying hot sand followed by rolling.

5.2. Single Bituminous Surface Treatment. Bituminous materials which can be used for SBST are as follows: cutback (RC-250, RC-800, or RC-3000); emulsion (RS-1, RS-2, CRS-1, or CRS-2); asphalt cement (AC-2.5 or AC-5); or road tar (RT-5 through -12). Aggregate gradations to be used are shown in Table 5.1.

5.3. Procedural Steps (SBST). The following steps should be conducted for placement of an SBST.

5.3.1. Prepare the area. Prior to applying an SBST, all failed areas shall be repaired and surfaces for treatment shall be thoroughly cleaned. The same procedures for prime and tack coats should be followed and are discussed in Paragraphs 4.2.1. and 4.5.1.

5.3.2. Apply the binder material. The binder (asphalt material) should be applied with an asphalt distributor. The distributor must be properly calibrated and the same precautions should be taken as discussed for sprayed asphalt treatments (Chapter 4). Application rates of the binder and aggregate for SBST are shown in Table 5.2.

Table 5.1. Aggregate Gradations for SBST

Sieve Size	% Passing by Weight, Gradation Designation		
	No. 1	No. 2	No. 3
1 in. (25.4 mm)	100	—-	—-
3/4 in. (19.1 mm)	90 - 100	100	—-
1/2 in. (12.7 mm)	20 - 55	90 - 100	100
3/8 in. (9.5 mm)	0 - 15	40 - 70	85 - 100
No. 4 (4.8 mm)	0 - 5	0 - 15	10 - 30
No. 8 (2.4 mm)	—-	0 - 5	0 - 10
No. 16 (1.2 mm)	—-	—-	0 - 5

Table 5.2. SBST Binder and Aggregate Application Rates

Gradation No.	Bituminous Material* gal/yd^2 (l/m^2)	Aggregate lb/yd^2 (kg/m^2)
1	0.40 - 0.50 (1.81 - 2.26)	40 - 50 (22 - 27)
2	0.30 - 0.45 (1.36 - 2.04)	25 - 30 (14 - 16)
3	0.20 - 0.35 (0.91 - 1.58)	20 - 25 (11 - 14)
* If an emulsion is used, increase the application rate by 10 percent.		

5.3.3. Apply the aggregate. The aggregate shall be immediately applied after binder material application. The aggregate can be applied with tailgate spreaders on dump trucks or by self-propelled hopper-type spreaders (Figures 5.1. and 5.2.). Spreaders should be calibrated to ensure proper aggregate application. Aggregate that is clean, dry, and free of dust or other undesirable material shall be used. Also, the aggregate should be hard, angular, and abrasion resistant.

5.3.4. Roll the aggregate. The aggregate shall be immediately rolled after application. A pneumatic-tire roller with tire pressures of 60 to 90 pounds per square inch (414 to 620 kilopascals) and appropriate size (weight) should roll the aggregate. To avoid crushing the aggregate, a pneumatic-tire roller should be used. A steel-wheel roller can be used; however, the weight shall be heavy enough to seat the aggregate but not crush it. The steel wheel will bridge low spots and may not properly seat the aggregate. Rolling should continue until all aggregate particles are properly seated.

5.3.5. Sweep the area. The treated area shall be allowed to cure for at least 24 hours before brooming to remove loose particles (Figure 5.3.). It is better to broom during the coolest portion of the day to prevent dislodging aggregate. Care should be taken to use only enough pressure on the broom to remove the loose particles.

5.4. Problem Areas (SBST). All equipment shall be properly calibrated before material placement. A test section can be used to ensure all equipment is in correct working order. To make clean and straight transverse joints, it is recommended that building paper be used where the spreading of the binder and aggregate begins and ends. After applications, the paper is removed and a straight edge is formed (Figure 5.4.). To prevent a buildup of aggregate along the longitudinal joint, the aggregate spread shall be stopped where the asphalt is a full thickness (Figure 5.5.). This distance varies according to the spray width of the nozzle, but it is usually

about 6 to 8 inches (150 to 200 millimeters). On the adjacent pass, aggregate should be applied along the full spray width. After completing the work and opening the treated area to traffic, speed limits should be posted to no more than 20 miles per hour (32 kilometers per hour) for a few days. This will ensure that the asphalt is fully cured and prevent dislodging of additional aggregate.

5.5. Multiple Bituminous Surface Treatment. This treatment is essentially the same as the SBST, except that more than one application of binder and aggregate is used. The most common treatment is the DBST. The same bituminous materials used for SBST can also be used for DBST (Paragraph 5-2). Aggregate gradations to be used are shown in the following table.

Table 5.3. Aggregate Graduations for DBST

Sieve Size	% Passing by Weight, Gradation Designation			
	No. 1	**No. 2**	**No. 3**	**No. 4**
1 in. (25.4 mm)	100	—-	—-	—-
3/4 in. (19.1 mm)	90 - 100	—-	100	—-
1/2 in. (12.7 mm)	20 - 55	100	90 - 100	—-
3/8 in. (9.5 mm)	0 - 15	85 - 100	40 - 70	100
No. 4 (4.8 mm)	0 - 5	10 - 30	0 - 15	85 - 100
No. 8 (2.4 mm)	—-	0 - 10	0 - 5	10 - 40
No. 16 (1.2 mm)	—-	0 - 5	—-	0 - 10
No. 50 (300µm)	—-	—-	—-	0 - 5

5.6. Procedural Steps (DBST). The following steps should be conducted for placement of a DBST.

5.6.1. Prepare the area. This is the same as for SBST (Paragraph 5.3.1.).

5.6.2. Apply the binder material. This is the same as discussed for SBST (Paragraph 5.3.2.), except two applications of binder and aggregate are placed with rates as follows:

Table 5.4. DBST Binder and Aggregate Application Rates

First Application		
Gradation No.	**Bituminous Material* gal/yd^2 (l/m^2)**	**Aggregate lb/yd^2 (kg/m^2)**
1	0.20 - 0.30 (0.91 - 1.36)	40 - 50 (22 - 27)
3	0.15 - 0.20 (0.68 - 0.91)	25 - 30 (14 -16)
Second Application		
Gradation No.	**Bituminous Material** gal/yd^2 (l/m^2)**	**Aggregate lb/yd^2 (kg/m^2)**
2	0.30 - 0.45 (1.36 - 2.04)	20 - 25 (11 - 14)
4	0.20 - 0.30 (0.91 - 1.36)	15 - 20 (8 - 11)

* If an emulsion is used, increase the application rate by 10 percent.
** Second application shall be 50 percent greater than first application.
NOTE: Graduations shall be used in pairs. If gradation 1 is used for the first application, then gradation 2 must be used for the second application and the same for gradations 3 and 4.

5.6.3. Apply the aggregate. This is the same as for SBST (Paragraph 5.3.3.).

5.6.4. Roll the aggregate. This is the same as discussed for SBST (Paragraph 5.3.4.).

5.6.5. Sweep the area. This is the same as for SBST (Paragraph 5.3.5.).

5.6.6. Apply second application. To apply the second application of binder and aggregate, the above steps (5.6.1.-5.6.5.) should be followed.

5.7. Problem Areas (DBST). The same problems for SBST are applicable to DBST. These problems are discussed in Paragraph 5.4.

5.8. Sandseal. This is another type of SBST; therefore, the same procedural steps for an SBST (Paragraph 5.3.) should be followed except the following aggregate gradations and application rates should be used:

Table 5.5. Aggregate Gradations for Sandseal

Sieve Size	% Passing by Weight, Gradation Designation	
	No. 1	No. 2
1/2 in. (12.7 mm)	—-	—-
3/8 in. (9.5 mm)	100	—-
No. 4 (4.8 mm)	85 - 100	100
No. 8 (2.4 mm)	10 - 40	10 - 40
No. 16 (1.2 mm)	0 - 10	0 - 10
No. 50 (300 μm)	0 - 5	0 - 5

Table 5.6. Sandseal Binder and Aggregate Application Rates

Application Rates		
Gradation No.	**Bituminous Material* gal/yd^2 (l/m^2)**	**Aggregate lb/yd^2 (kg/m^2)**
1	0.20 - 0.35 (0.91 - 1.58)	20 - 25 (11 - 14)
2	0.15 - 0.25 (0.68 - 1.13)	15 - 20 (8 - 11)
3	0.15 - 0.25 (0.68 - 1.13)	10 - 15 (5 - 8)
* If an emulsion is used, increase the application rate by 10 percent.		

5.9. Sand Application and Rolling. This SBST variational method can be used to repair bleeding pavement. The following steps should be conducted.

5.9.1. Apply hot sand. Sand should be heated to above 275 degrees Fahrenheit (135 degrees Celsius) and then the sand can be spread with a tailgate or box spreader, or by hand. The recommended application rate is 10 to 15 pounds per square yard (5 to 8 kilograms per square meter).

5.9.2. Roll the sand. Immediately after spreading the sand, it shall be rolled with a pneumatic-tire roller.

5.9.3. Sweep excess material. After the treated area has sufficiently cooled, an appropriate sweeping method should be used to remove excess sand.

Figure 5.1. Applying aggregate with tailgate spreader on dump truck

Figure 5.2. Applying aggregate with self-propelled hopper-type spreader

Figure 5.3. Brooming the treated area

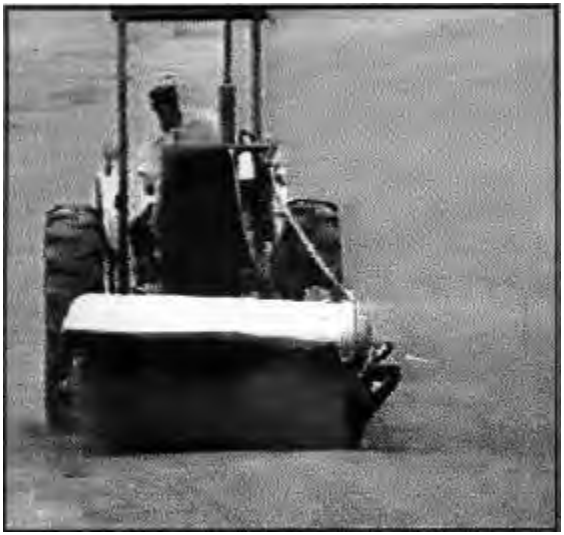
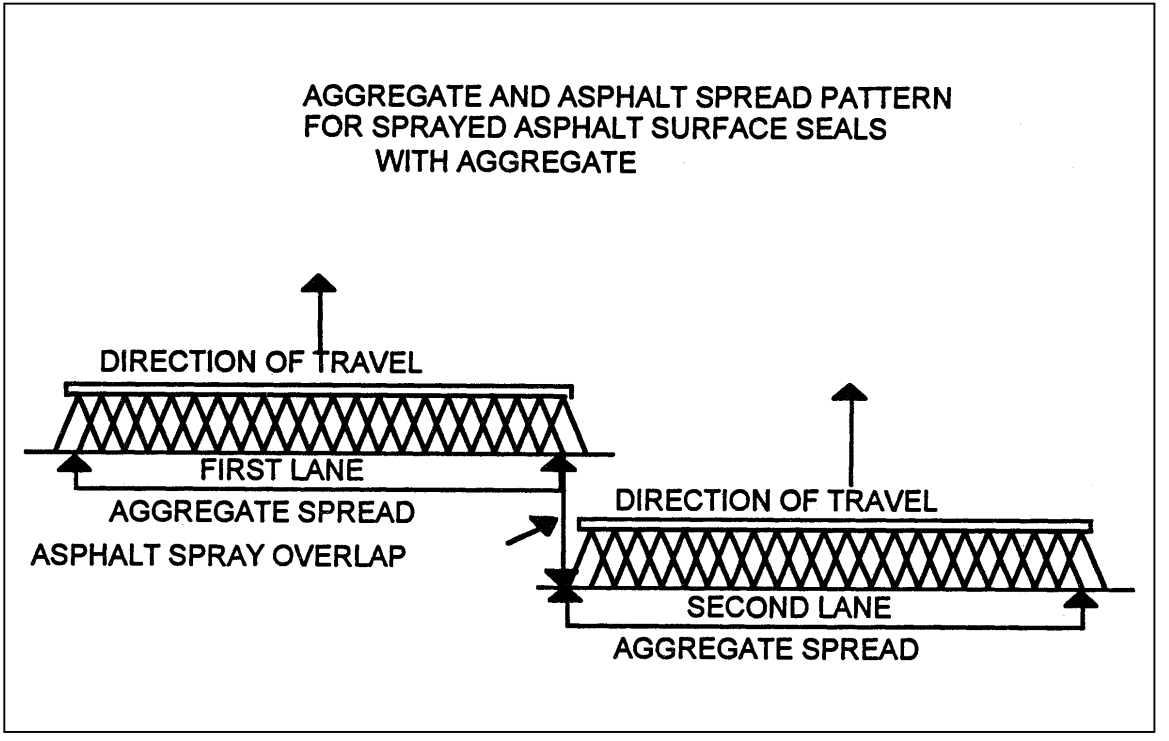


Figure 5.4. Straight edge formed after building paper removed

Figure 5.5. Aggregate and sprayed asphalt spead pattern



CHAPTER 6

ASPHALT SLURRY SEALS

6.1. Introduction. A slurry seal is a mixture of asphalt emulsion, aggregate, water, and mineral filler. Slurry seals are used to seal and protect worn, weathered, and cracked pavement from the effects of further weather and traffic. Another use is to reduce skid problems. A slurry seal is not a normal repair for airfields or heavy traffic areas. The MAJCOM or TSMCX pavement engineer should be contacted prior to using a slurry seal on these areas.

6.2. Mixture Materials. The type emulsions that can be used in a slurry seal are SS-1, SS-1h, CSS-1, or CSS-1h. Aggregate gradations to be used are shown in the following table.

Table 6.1. Aggregate Gradations for Slurry Seals

Sieve Size	% Passing by Weight, Gradation Designation		
	No. 1	No. 2	**No. 3**
3/8 in. (9.5 mm)	100	—-	—-
No. 4 (4.8 mm)	70 - 90	100	—-
No. 8 (2.4 mm)	45 - 70	78 - 95	100
No. 16 (1.2 mm)	28 - 50	55 - 80	70 - 94
No. 30 (600 µm)	19 - 34	35 - 60	45 - 73
No. 50 (300 µm)	12 - 24	20 - 40	25 - 50
No. 100 (150 µm)	7 - 16	10 - 22	10 - 25
No. 200 (75 µm)	4 - 12	4 - 12	4 - 14

If a mineral filler is used in the slurry, a portland cement or hydrated lime should be used. The filler tends to improve the stability of the mixture. If stability or segregation problems occur, mineral filler at 0.4 to 0.5 percent of the total mixture should be used. Only potable water shall be used. Water is the primary control for workability of the mixture.

6.3. Procedural Steps. The following are steps for placement of a slurry seal.

6.3.1. Prepare the surface. All loose material (including any loose or flaking paint), dirt, and vegetation shall be removed from the surface. Cracks greater than 1/8 inch (3 millimeters) wide shall be sealed. During sealing, the sealant should be placed 1/8 to 1/4 inch (3 to 6 millimeters) below the surface. After sealing all cracks and cleaning the surface, a very light tack coat should be sprayed at a rate of 0.05 to 0.10 gallons per square yard (0.23 to 0.45 liters per square meter) and allowed to fully cure.

6.3.2. Apply the slurry. Immediately before applying the slurry, a fog spray of water should be applied to the surface with the spray bar on the slurry machine. There should be no standing water after the spray. The spray should be adjusted to compensate for temperature, surface texture, humidity, and dryness of the surface. The slurry shall be applied with a slurry machine (Figure 6.1.). The slurry machine is a self-propelled, continuous-flow mixing unit. It should be capable of delivering the proper amount of aggregate, water, mineral filler, and emulsion to the mixing unit (Figure 6.2.). The mixing unit is either a single or double pugmill mixer. The mixing unit discharges the material into the spreader box that is equipped with flexible squeegees and width adjustment. Other parts of the machine include the spray bar for wetting the pavement and an aggregate prewetting device. Most of the time, a burlap drag is located behind the spreader box to improve the joints and overall appearance of the mixture. The slurry is applied from 1/8 inch (3 millimeters) and is usually no more than 1/4 inch (6 millimeters) thick in one pass. If

more than one pass is applied, the previous layer should fully cure before applying the second application.

6.3.3. Roll the slurry. The slurry shall be rolled to reduce the voids, limit surface imperfections, and increase the slurry's resistance to water. The rolling should be performed after the slurry has cured enough to support the roller without removing any of the slurry mixture. A 5-ton (4,540-kilogram) pneumatic-tire roller with tire pressures of 50 pounds per square inch (345 kilopascals) should be used to roll the slurry.

6.3.4. Cure the slurry. The time to allow for curing will vary according to the amounts of the emulsion and aggregate. The slurry could cure by evaporation of water from the surface, by deposition of asphalt on the aggregate which frees the water, or by a combination of these. If curing is from top to bottom, the material at the top will cure faster than the material at the bottom. Before opening the treated area to traffic, the slurry seal shall be fully cured.

6.4. Problem Areas. To ensure proper slurry machine calibration and correct mixture, a test strip should be used. When hand applying the slurry, it should not be overworked; this causes the emulsion to break prematurely. If possible, the second lane should be applied while the edge of the previous lane is still fluid and workable. If the previous lane's edge is not workable, then allow the slurry material to cure enough for the spreader box not to damage the previous lane. Since material buildup on the burlap drag causes streaking and gouging, the burlap drag should be kept clean and it should be replaced when necessary. The flexible lining of the spreader box should be inspected for wear or accumulation of cured slurry.

Figure 6.1. View of slurry seal machine

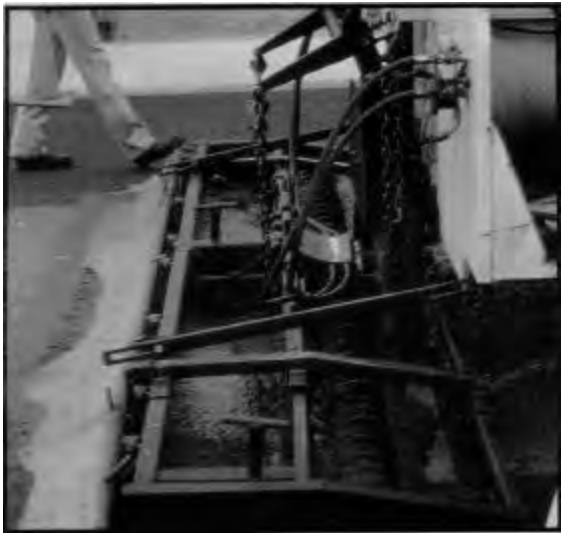
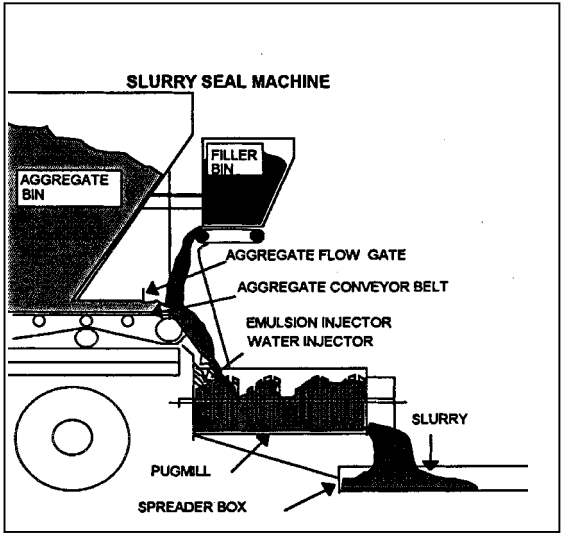


Figure 6.2. Slurry seal machine



CHAPTER 7

PATCHING (FILLING RUTS AND DEPRESSIONS)

7.1. Introduction. Ruts and depressions are frequently repaired by filling the distressed areas with layers of asphalt. The procedure is usually a temporary repair. If the rut or depression area is accompanied by alligator cracking, full- or partial-depth repairs should be conducted.

7.2. Procedural Steps. The following steps should be conducted to repair a rut or depression.

7.2.1. Determine repair boundaries. If a depression or rut is to be repaired, the repair area should extend to where the area is the same elevation as the surrounding pavement. For repair of other distresses, the repair should extend beyond the distress (usually 1 foot (300 millimeters)) and into sound pavement.

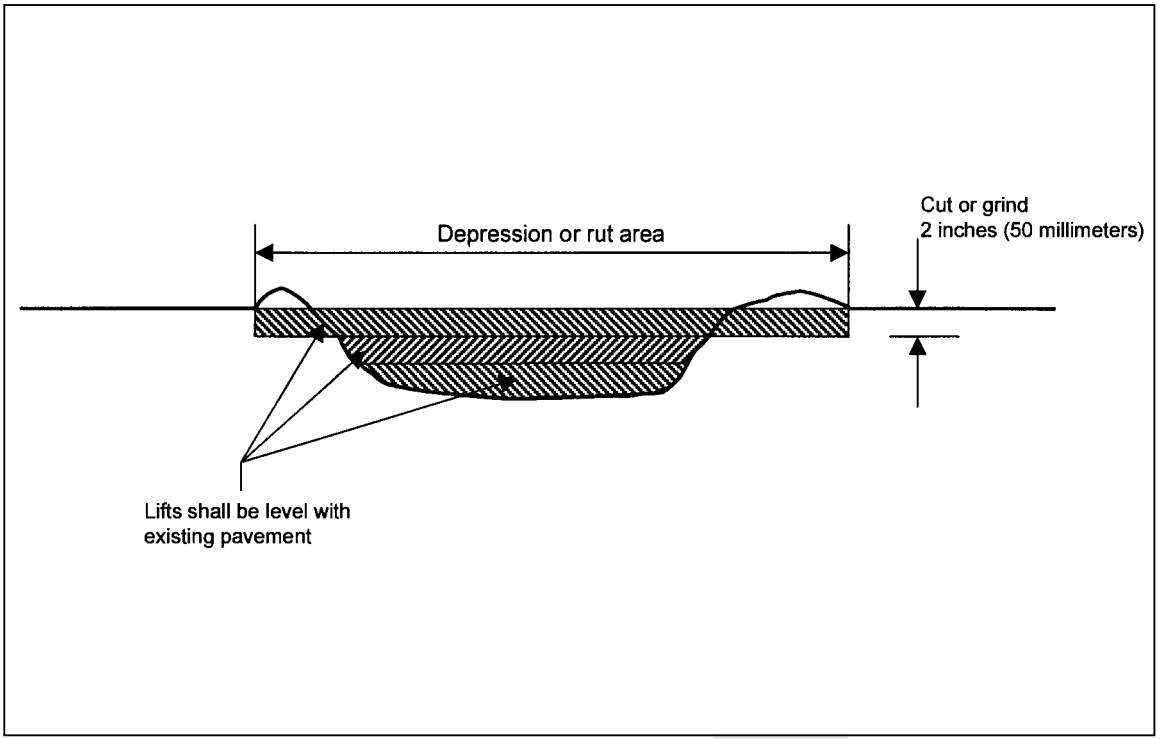
7.2.2. Cut the patch and remove pavement. For repair of depressions and ruts, the edges shall be sawed or a grinder can be used to grind down the pavement. A vertical edge should be at least 2 inches (50 millimeters) deep. If the edges are saw cut, a lightweight jackhammer should be used to remove the pavement along the edges by placing the jackhammer about 3 inches (75 millimeters) inside the patch area with the hammer toward the edge. This will avoid damaging the vertical edge.

7.2.3. Prepare area. After removal of the pavement from the patch area, the area should be thoroughly cleaned with high-pressure air, brooms, water, or combinations of these. The area should also be dry before applying the tack coat. After the repair area is clean and dry, a tack coat is applied to the edges and bottom of the patch area. Apply the tack as discussed in Paragraph 4.5.2. The tack shall be allowed to cure.

7.2.4. Place and compact repair material. For the patch to be most effective, a good-quality hot-asphalt plant mix should be used. If the repair is deep enough, the asphalt should be placed in lifts of no more than 2 to 3 inches (50 to 75 millimeters) thick. To repair ruts, level lifts should fill the ruts rather than lifts conforming to the shape of the rut (Figure 7.1.). Use the appropriate equipment to compact the asphalt. On the final lift placement, the patch area should be overfilled to allow for compaction. When fully compacted, the patch should be level or within 1/8 inch (3 millimeters) of the surrounding surface. A pneumatic-tire roller works best for compacting material in ruts and depressions. If hot-mix material is not available, a cold-mix material can be used; however, the patch will not have a long service life. During inclement weather conditions, it is recommended that cold-mix materials be used for repairs.

7.3. Problem Areas. The edges of the patch shall be as straight and vertical as possible. Too much tack coating should be avoided. When repairing a rut or depression, the asphalt material should be properly placed to ensure the repair is level with the surrounding pavement.

Figure 7.1. Correct method for filling ruts and depressions in lifts



CHAPTER 8

POROUS FRICTION SURFACES

8.1. Introduction. A porous friction surface (PFS) is an open-graded asphaltic concrete wearing surface containing a large amount of air voids that allow water to drain vertically and laterally through the pavement structure (Figure 8.1.). These surfaces are usually 3/4 to 1 inch (19 to 25 millimeters) thick and the large void content provides a means to prevent hydroplaning at high speeds. The surface texture of the PFC provides for excellent skid resistance and decreases the tire spray under wet conditions. Several procedures to repair a PFS are presented in the following paragraphs.

8.2. Sealing Cracks. The guidelines for sealing cracks in a PFS are different from a normal asphalt surface. The materials used for sealing cracks on a PFS are the same as for a normal asphalt pavement. The following steps should be conducted for sealing cracks on a PFS.

8.2.1. Prepare the crack. To prepare the crack, all loose material shall be removed and the crack should be free of dust and dirt.

8.2.2. Seal the crack. The same sealant placement procedures shall be followed as for an asphalt surface (UFC 3-270-02, “Asphalt Crack Repair”). If the crack is 1/4 inch (6 millimeters) wide or less, the crack should not be sealed unless loose debris is causing an FOD problem. Cracks from 1/4 to 3/4 inch (6 to 19 millimeters) should be sealed if they are raveling and causing an FOD problem. Cracks greater than 3/4 inch (19 millimeters) wide shall be filled with a PFS asphalt mixture and rolled with a steel-wheel roller. Only seal longitudinal cracks when regular sweeping methods no longer remove all loose aggregate from the surface. The loose aggregate could block internal drainage. Transverse cracks should be sealed except those perpendicular to the water flow. In any case, do not seal the joint if it will interfere with water drainage.

8.3. Patching PFS. If correctly performed, a PFS patch should be virtually indistinguishable from the remainder of the surface. The following steps shall be conducted for patching PFS.

8.3.1. Remove defective PFS. Sawing shall not be performed to patch a PFS. It is recommended that a milling machine be used to remove any defective PFS. The full depth and extent of PFS damage shall be milled.

8.3.2. Clean and tack repair area. Remove the defective material and, if necessary, repair the underlying pavement. The repair area should be thoroughly cleaned before placing the tack coat. A light tack coat should be applied to the bottom but not the edges.

8.3.3. Place patch material. The repair material should conform as closely as possible to the existing PFS. After material placement, it should be rolled by using the same method as the original construction. A cold-mix asphalt can be used for a temporary repair.

8.4. Raveling Control. A procedure that will help control raveling of the porous friction surface, until replacement, is a very light spray application of asphalt emulsion. If this procedure is performed, care should be taken not to hinder drainage of the PFS.

8.5. Patching Using Standard Hot-Asphalt Plant Mix. If a standard hot-asphalt plant mix is used to repair a PFS, the following steps shall be taken.

8.5.1. Mark the repair area. The boundaries of the repair shall be determined and marked for saw cutting. The patch must be diamond shaped with a point of the diamond at the high elevation (Figure 8.2.). This will allow water to flow around the patch area.

8.5.2. Remove defective PFS. The area should be sawed to the thickness of the porous friction surface. Defective material should be removed and care taken not to destroy the edges of the patch.

8.5.3. Place patch material. The sides and bottom of the patch area shall be tack coated; however, do not over-tack. After the tack coat has cured, a well-graded hot-asphalt plant mix shall be placed and compacted.

Figure 8.1. View of a porous friction surface (PFS)

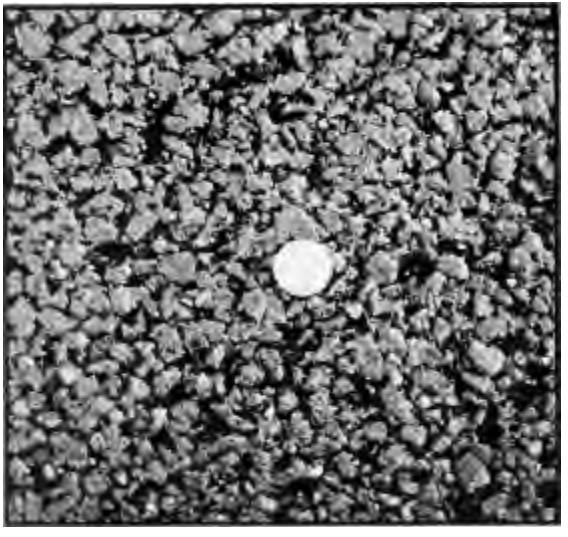


Figure 8.2. Porous friction pavement patch using hot-asphalt plant mix