800 - DEFINITIONS AND ABBREVIATIONS

800.1
Definitions

Wherever in these specifications, or in other contract documents, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

1. **Agreed or Approved -** Official agreement or approval by use of a written document issued by the Government. Agreements also require signature of Service Provider's Representative and are dated.
2. **Base course -** The layer or layers of material placed on a subbase or a subgrade to support a surface course. (See Illustration of Road Maintenance Terms.)
3. **Berm -** A curb or dike that controls roadway runoff water or delineates traffic direction.
4. **Broad based dip** - A shallow ditch placed across the roadbed to remove water from the roadbed surface that can be driven across by high clearance vehicles; usually placed diagonal to the centerline.
5. **Catch Basin**. The area immediately adjacent to inlet invert of the culvert.
6. **Channel.** A natural waterway leading into or away from a culvert or bridge.
7. **Cross ditch.** A shallow ditch placed across the roadbed to remove water from the roadbed surface that can be driven across by full-size pickups or other high clearance vehicles; usually placed diagonal to the centerline.
8. **Culvert.** Any structure that provides a passageway, drain, or waterway under a road or embankment.
9. **Lead-off ditch**. A ditch used to remove water from roadside drainage ditches, the roadway, cattleguards, or drainage structures such as culverts and drainage dips.
10. **Ditch.** A relatively long narrow excavation placed to collect or disperse water.
11. **Drainage dip.** A drainage structure that was previously constructed within the roadbed surface to form a uniform depression that allows routine passage of vehicles while diverting water from the traveled way.
12. **Drainage ditch.** A ditch located parallel to and abutting the roadbed.
13. **Drainage structure.** A term identifying manufactured devices placed to control water movements.
14. **Drawings**. Illustrations showing details of required work.
15. **Equipment**. All machinery, operating supplies and tools necessary for the proper performance and acceptable completion of the work.
16. **Excess Material**. Material from the roadway in excess to that needed for maintenance of roadway.
17. **Foreslope.** The slope of the ditch section nearest to the traveled way.

18. **Grade.** The vertical alignment of the top surface of the road.
19. **Highway Vehicles.** Vehicles such as, passenger cars and high clearance vehicles.
20. **High Clearance Vehicles**. Vehicles such as, pickups, 4x4s, and log trucks.
21. **Hydrologic Function.** Physical properties of the occurrence and movement of water on the earth's surface and that part which crosses transportation systems.
22. **Materials.** Any substances specified for use in the performance of the work.
23. **Measurement**. The process of identifying the dimensions, quantity, or capacity of an item.
24. **Nominal Dimensions or Weights.** The numerical values shown on the drawings or in the specifications as measurements for the work.
25. **Original Contract Quantities**. Those estimated quantities shown in the Schedule of Items as awarded.
26. **Patching.** Minor repairs.
27. **Paved Surface or Pavement.** Denotes asphalt, concrete, or other stabilized materials excluding natural aggregates. Dust palliative treatments are not considered as pavement.
28. **Right-of-Way**. A general term denoting (1) the privilege to pass over land in some particular line (including easement, lease, permit, or license to occupy, use, or traverse public or private Lands), or (2) real property necessary for the project, including roadway, buffer areas, access, and drainage areas.
29. **Roadbed.** The portion of a road between the intersection of the subgrade and side slopes, excluding that portion of the ditch below the subgrade.
30. **Road Listing.** A preliminary listing of road locations and any established work priorities.
31. **Schedule of Items**. A schedule in the contract that contains a listing and description of maintenance items, quantities, units of measure, methods of measurement, unit price, and amount.
32. **Shoulder.** The portion of the roadway continuous to the traveled way for accommodation of stopped vehicles, emergency use, and lateral support of travel way structure.
33. **Slough or Slide**. Material deposited on the roadway that may need to be repositioned or removed.
34. **Slump**. A localized portion of the roadbed that has slipped, or otherwise become lower than the adjacent roadbed, and constitutes a hazard to traffic.
35. **Standard Specifications.** Specifications for all divisions of work.
36. **Subgrade.** Top surface of roadbed upon which the pavement structure, shoulders, and curbs are constructed.

37. **Traveled Way.** The portion of the roadway designated for the movement of vehicles, exclusive of shoulders but including turnouts and curve widening.

38. **Turnouts**. A short auxiliary lane on a one-lane road provided for passage of meeting vehicles.

39. **Unit of Measure.** The unit and fractions of units shown in the Schedule of Items.

40. **Unsuitable Material**. Material removed during maintenance, which must be disposed of in designated locations. Includes material with substantial amounts of vegetation or other objectionable material.

41. **Waterbar**. A deeper type cross ditch, which is not intended for standard passenger vehicles.

42. **Work Schedule.** The Service Provider's current schedule for work progression.

800.2
Abbreviations

Whenever in these specifications, or in other contract documents, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows: (Reference to a specific standard or specification shall mean the latest addition or amendment thereto in effect on date of Invitation for Bids.)

AASHTO – American Association of State Highway and Transportation Officials.

ASTM – American Society for Testing and Materials.

EPA – Environmental Protection Agency.

FAR – Federal Acquisition Regulation System.

FED SPEC – Federal Specifications.

FP-03 – Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects.

FSSS- Forest Service Supplemental Specifications

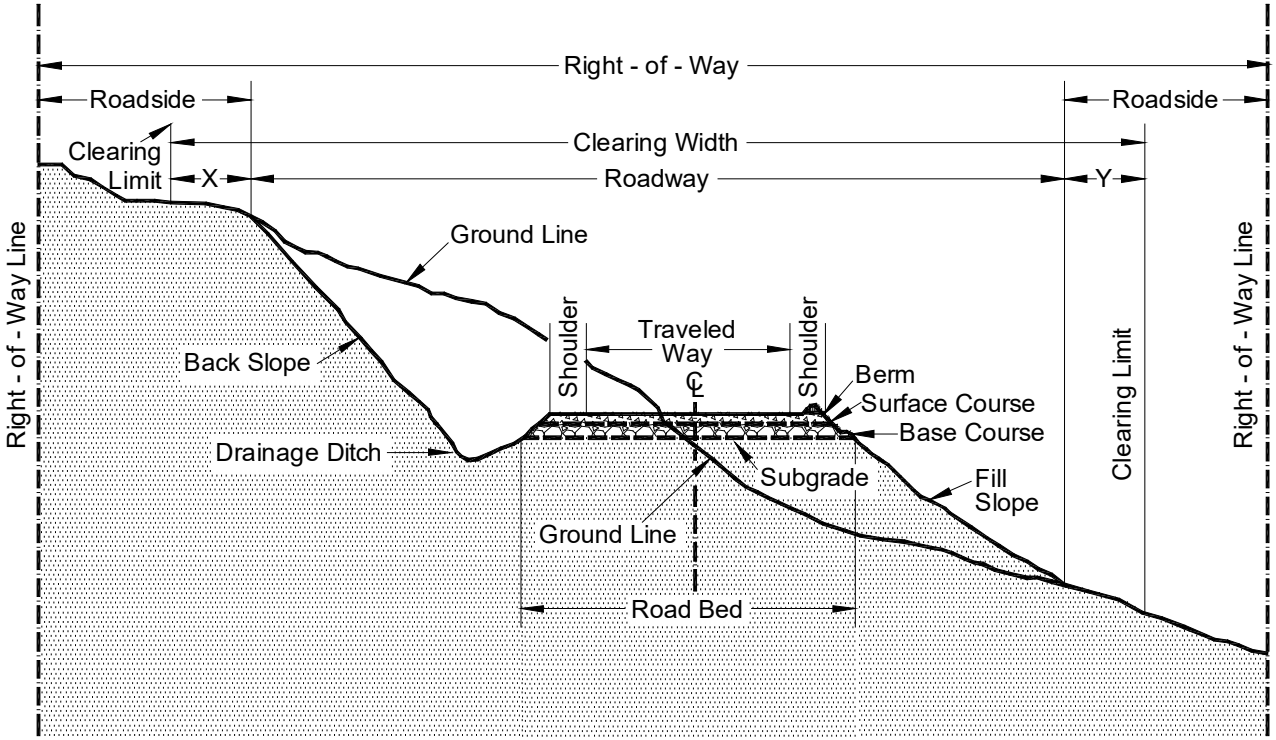
MSHA – Mine Safety Health Administration.

MUTCD – Manual of Uniform Traffic Control Devices.

NBS – National Bureau of Standards.

OSHA – Occupational Safety and Health Act.

Illustration of Road Maintenance Terms.



Note: Shapes and dimensions will vary to fit local conditions.
See drawings for typical sections.
X and Y denote clearing outside of roadway.

801 – Quantity Measurement Terms

1. U.S. Customary Units of measure are used in conjunction with these specifications.

2. The methods of measurement and computation will be those necessary to accurately determine the quantities of materials furnished and work performed.

3. All items, which are measured by the feet, will be measured parallel to its longitudinal centerline, unless otherwise shown on the drawings.

4. A station when used as a definition of term or measurement will be one hundred feet, or a precise location along a survey line.

5. Miles will, in the absence of known distances from existing plans or surveys, be determined by the Government using a calibrated survey odometer or equal substitute operated on the traveled way at or parallel to road centerline.

6. The term "ton" means 2000 pounds. Trucks used to haul material measured by truck weight shall be weighed empty at least once daily, and each truck shall bear a plainly legible identification mark. Weigh tickets furnished by the Contractor from certified scales will be used to determine weight measurements.

7. Materials measured by the cubic yard in the hauling vehicle shall be measured therein at the point of delivery. Vehicles may be of any size or type, provided that the box is of such shape that the actual volume may be readily and accurately determined.

8. Measurement by the acre will use the length and width treated. Measurement of width will approximate significant slope breaks, but will not include minor deviations along the slopes. The measured slope distance for the length will multiply width treated and converted to a standard 10,000 square yard or acreage value of the surface area treated.

9. Measure square yard with horizontal longitudinal and traverse measurements.

10. The term "lump sum" when used in the Schedule of Items means the complete unit as required by or described in the contract.

11. Measurement will be made of each item or unit of work, as shown in the Schedule of Items, completed and accepted in accordance with the contract provisions, specifications, and drawings.

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813 SPOT SURFACING

813.01
Service Required

Load, haul, and place surface material to repair or stabilize road surfaces.

813.02
Performance Standard

A. Spot surfacing is complete when the designated quantity of the ordered material has been placed.

B. All materials transported onto National Forest System land will be weed-free. Written documentation of methods used to determine the weed-free status of any and all materials furnished by the contractor will be furnished to the Contracting Officer before transport of any materials onto National Forest System land.

813.03
Location of Work

As specified on roads listed on the ROAD LISTING, SHOWN ON THE PLANS, or as ordered by the Contracting Officer.

813.04
Measurement

Measurement under this Section will be made by the total number of units for each item listed in the SCHEDULE OF ITEMS completed and accepted.

A. The quantity will be the number of cubic yards measured in the vehicles, or square yards of aggregate placed.

B. Material measured by the ton shall be verified by certified weight tickets.

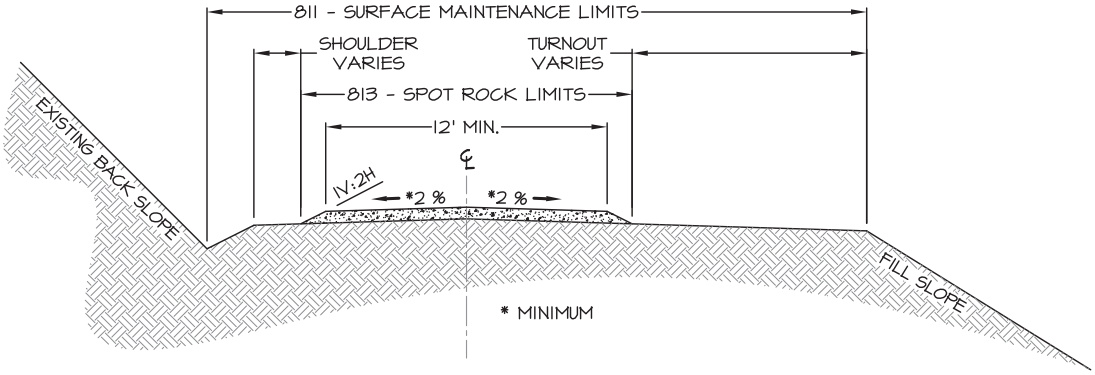
813.05
Payment

The accepted quantities will be paid at the contract price per unit of measurement for the Section 813 pay items listed in the schedule of items. Payment will be full compensation for the work prescribed in this Section.

Pay Item		Pay Unit
813(1)	Spot Surfacing, Gradation _____	Cubic Yard
813(2)	Spot Surfacing, Gradation _____	Square Yard
813(3)	Spot Surfacing, Gradation _____	Ton

813.04
Acceptable Quality Levels

Description	Major Defect	Minor Defect	Allowable Defects		Required Action	
			Major	Minor	Major	Minor
Depth of Aggregate	Dimension of spot surfacing deviates by more than 1" from depth specified. Or less than 1" from dimension specified but is consistently high or low.	Dimension of spot surfacing deviates by 1" or less than from depth specified and not consistently high or low.	0	N/A	If depth is low, correct placement of aggregate to specified dimensions. If depth is high only pay for ordered amount	Accept aggregate as placed, pay only for delivered quantities.
Width of Aggregate	Dimension of spot surfacing is less than specified width or more than 1' wider than specified.	Dimension of spot surfacing is up to 1' wider than specified but not consistently wide.	0	N/A	If width is narrow, correct placement of aggregate to specified dimensions. If width is too wide reshape.	Accept aggregate as placed, pay only for delivered quantities.
Length	Dimension of spot surfacing is shorter than specified length or more than 100' longer than specified.	Dimension of spot surfacing is shorter than specified length or up to 100' longer than specified.	0	N/A	If length is shorter than specified, correct placement of aggregate to specified dimensions. If too long pay only for ordered amount.	Accept aggregate as placed, pay only for delivered quantities.
Compaction	Visible displacement occurs under heady spreading equipment	N/A	0	N/A	Rework	N/A
Aggregate Quality	Does not meet specified gradation or durability requirements and is not suitable for intended use	Does not meet specified gradation or durability requirements and is suitable for intended use	0	N/A	Reject and replace	Accept but may reduce payment.
	Material source does not meet weed free requirement	N/A	0	N/A	Reject source	N/A
Finish Quality	Spot surfacing doesn't conform to the adjacent road segments and traffic is impeded.	Spot surfacing generally conforms to the adjacent road segments, but traffic may be slowed.	0	0	Reshape or recompact surfacing as needed.	Reshape or recompact surfacing as needed.



SURFACE MAINTENANCE & SPOT ROCK TYPICAL

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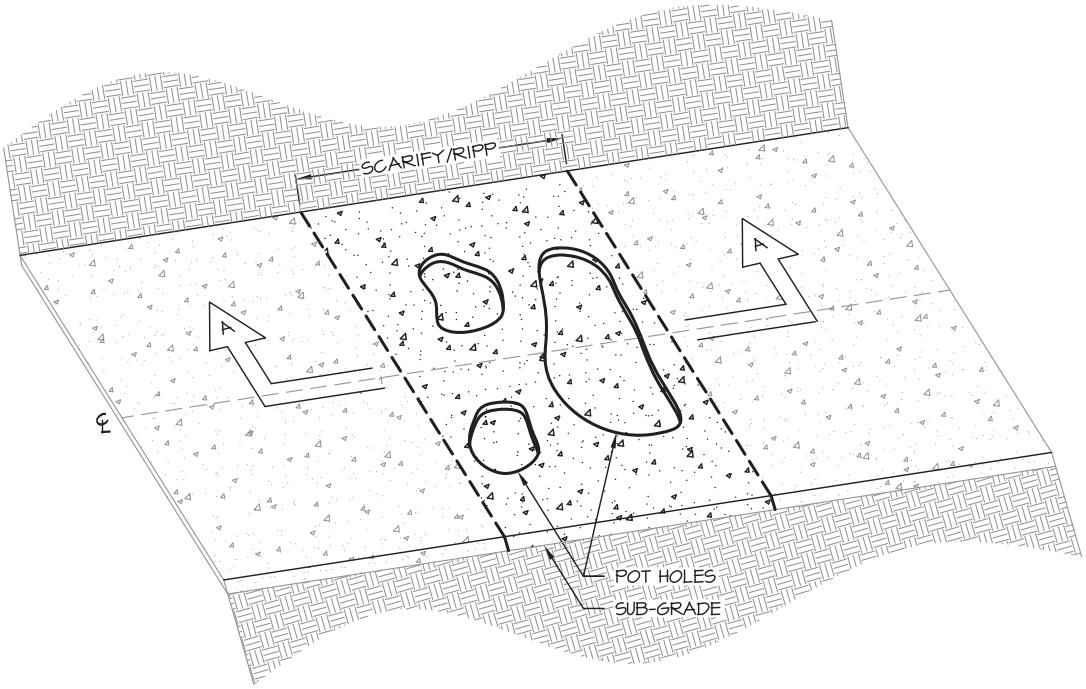

POT HOLE TREATMENT TYPICAL

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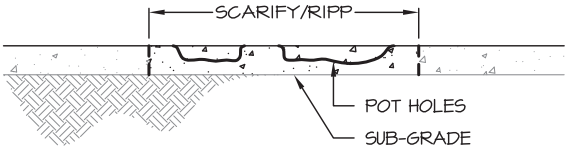

SECTION A - A

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NOTES:

1. GRADING - CROWN ROADS WITH A 2 % - 3 % CROWN. FOR IN-SLOPE/OUT-SLOPE ROADS SLOPE WITH A 2 % - 3 % CROSS SLOPE OVER THE ENTIRE ROAD WIDTH.
2. SPOT ROCK - PLACE MATERIAL THE FULL ROAD WIDTH BY END DUMPING TO A MINIMUM DEPTH OF 3".
3. DITCHES - CLEAN DITCHES THAT DO NOT REQUIRE END HAUL AND WHICH CAN EASILY BE PUSHED WITH A GRADER AS DIRECTED BY CONTRACTING OFFICER. MATCH ORIGINAL DITCH DIMENSIONS.
4. CLEANING DITCHES UNDER 811 - SURFACE MAINTENANCE IS DEFINED AS A MINIMAL EFFORT TO OPEN UP RESTRICTED DITCHES AND IS NOT A SUBSTITUTE FOR INTENSIVE DITCH CLEANING, WHEN REQUIRED, AS COVERED UNDER 834 - ROADWAY DRAINAGE SYSTEM MAINTENANCE.
5. POT HOLES - PRIOR TO GRADING AND SPOT ROCK ACTIVITIES, SCARIFY/RIPP ALL POT HOLES, FULL WIDTH, DOWN TO SUB-GRADE OR FIRM GROUND AS DIRECTED BY CONTRACTING OFFICER.

811-F2 & 813-F2 TYPICALS (12/11)

814 ASPHALT SURFACE MAINTENANCE

814.01
Service Required

Repair and cleaning of pavement surfaces.

814.02
Performance Standard

This work is complete when the pavement is clean and free of cracks, potholes, and surface irregularities.

Follow industry standards as outlined in the Asphalt Institute Manual Series Number 16.

814.03
Location of Work

As specified on roads listed on the ROAD LISTING, SHOWN ON THE PLANS, or as ordered by the Contracting Officer.

814.04
Measurement

Measurement under this Section will be made by the total number of units for each item listed in the SCHEDULE OF ITEMS completed and accepted.

A. Single Lane Roads: The work activity will be measured along the centerline of the roadway. Turnouts are incidental. Measurement will be to the nearest one-tenth (0.1) mile.

B. Double Lane Roads: The work activity will be measured along the centerline of the roadway. Measurement will be to the nearest one-tenth (0.1) mile.

C. Road Mile: Work activity will be measured along the centerline of the road regardless of the number of lanes.

D. Ton: Material measured by the ton shall be verified by certified weight tickets.

E. Linear Foot: Work activity by the linear foot will be measured using standard survey methods rounded to the nearest one (1) foot.

814.05
Payment

A. The accepted quantities will be paid at the contract price per unit of measurement for the Section 814 pay items listed in the schedule of items. Payment will be full compensation for the work prescribed in this Section.

Pay Item	Pay Unit
814(1) Pothole Patching	Ton
814(2) Skin Patching	Ton
814(3) Crack Sealing	Linear Foot
814(4) Crack Sealing	Mile
814(5) Paved Surface Cleaning (Single Lane)	Mile
814(6) Paved Surface Cleaning (Double Lane)	Mile
814(7) Paved Surface Cleaning	Each

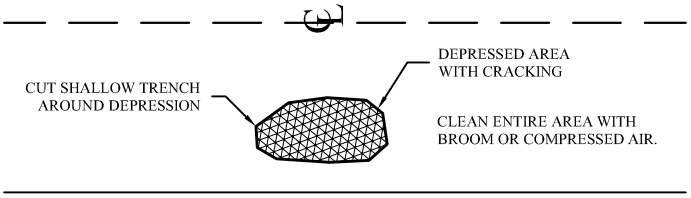
814.05

Acceptable Quality Levels

Description	Major Defect	Minor Defect	Allowable Defects		Required Action	
			Major	Minor	Major	Minor
Pothole Patching	Finished elevation does not match adjoining segments by more than 1/4 inch	N/A	0	N/A	Rework	N/A
	Patched material does not properly adhere to adjacent surfaces	N/A	0	N/A	Rework	N/A
	Area to be patched is not properly prepared	N/A	0	N/A	Rework	N/A
Skin Patching	Finished skin patch does not make smooth transition with adjoining pavement.	N/A	0	N/A	Rework	N/A
	Patched material does not properly adhere to adjacent surfaces	N/A	0	N/A	Rework	N/A
	Area to be patched is not properly prepared	N/A	0	N/A	Rework	N/A
Crack Sealing	Crack Sealant does not completely fill the cracks greater than 1/4 inch	Crack Sealant does not completely fill the cracks 1/4 inch or less	0	Less than 10%	Rework	Rework
	Crack sealant does not properly adhere to adjacent surfaces	N/A	0	N/A	Rework	N/A
	Area to be sealed is not properly prepared	N/A	0	N/A	Rework	N/A
Surface Cleaning	More than 5% of surface is not cleaned as specified	Less than 5% of surface is not cleaned as specified	0	Less than 5%	Rework	Accept
Asphalt Quality	Product and gradation does not meet Specifications and is not suitable for job.	Product and gradation does not meet Specifications but is otherwise suitable for job.	0	Less than 10%	Reject and replace	Rework
Work Area Management	Not following approved safety plan which may include signs, flaggers, and other temporary traffic control measures	Not following approved safety plan which may include signs, flaggers, and other temporary traffic control measures	0	0	Suspend work until in compliance	Suspend work until in compliance

SKIN PATCHING

1.



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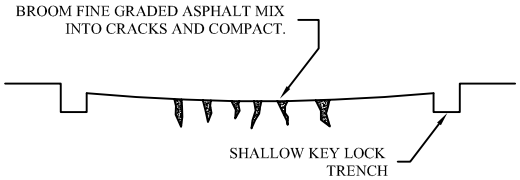

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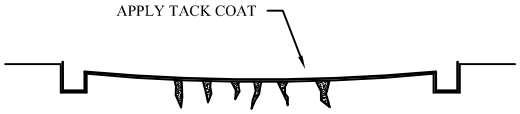

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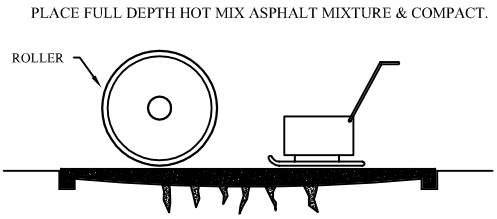

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POTHOLE/FULL DEPTH REPAIR

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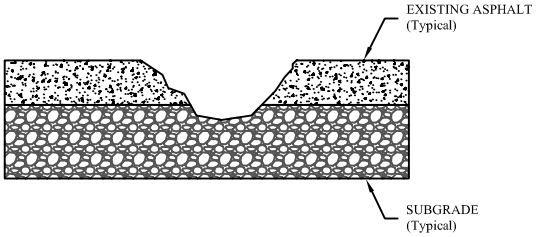

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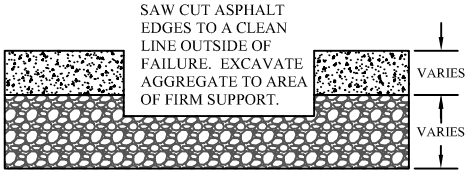

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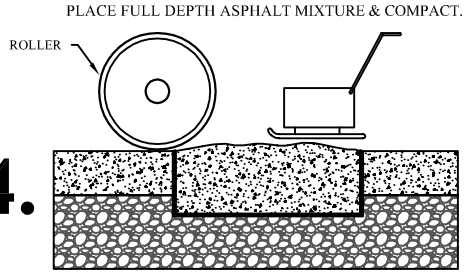

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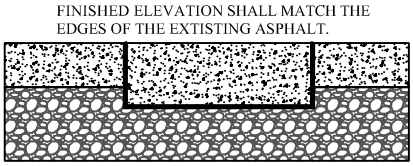

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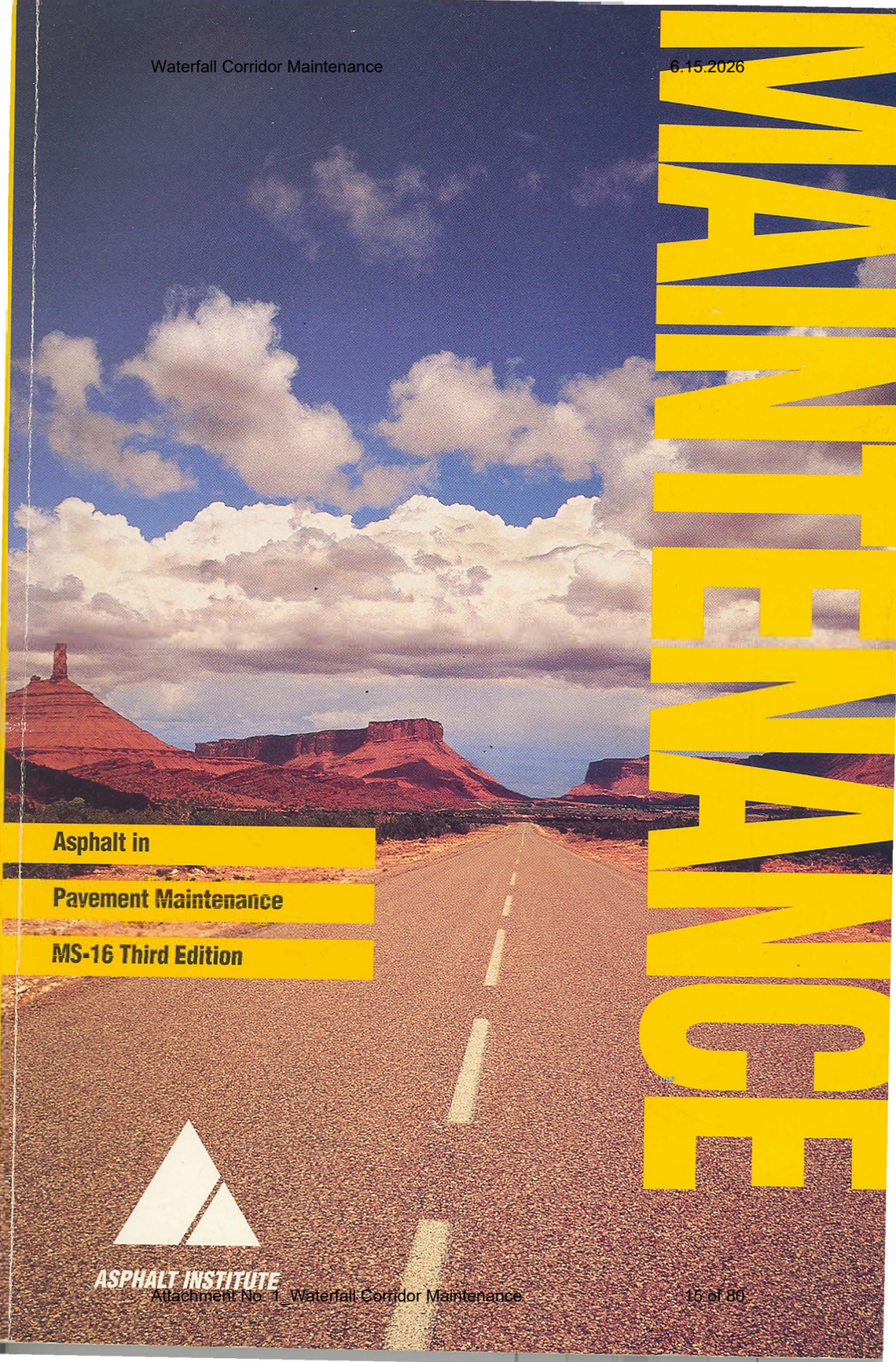
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE MT. BAKER–SNOQUALMIE N.F.		DATE: APRIL 5, 2011
		DRAWING: 2 OF: 8
APPROVED:	DWG NO: 814–1	DRAWN BY: J. MORAN
Title: Attachment No. 1 Waterfall Corridor Maintenance PAVEMENT REPAIR		FILE NAME: 814–1



Asphalt in Pavement Maintenance

MS-16 Third Edition

ASPHALT INSTITUTE

Mai. '96

Asphalt in Pavement Maintenance

MAINTENANCE

Asphalt Institute
Manual Series No. 16 (MS-16)
Third Edition

The Asphalt Institute can accept no responsibility for the inappropriate use of this manual. Engineering judgment and experience must be used to properly utilize the principles and guidelines contained in this manual, taking into account available equipment, local materials and conditions.

All reasonable care has been taken in the preparation of this manual; however, the Asphalt Institute can accept no responsibility for the consequences of any inaccuracies which it may contain.

Photographs and drawings of equipment used in this publication are for illustration only and do not imply the preferential endorsement of any particular make or model by the Asphalt Institute.

Printed in the U.S.A.

Pavement maintenance is an essential activity for the long-term life of pavement structures. Properly timed and constructed pavement maintenance procedures can be used to extend the service life of all pavements.

This manual has been prepared for those directly concerned with pavement maintenance. It provides useful and practical information about methods, equipment and terminology that applies to the use of asphalt in the maintenance of all types of pavement structures, including highways and shoulders; streets and parkways; airfield runways, taxiways, and aprons; parking lots and access roads; and driveways and alleys.

The maintenance of drainage facilities is discussed only for issues related to the drainage of the pavement structure itself. Not covered in this manual are pavement striping or painting; curbs and gutters; maintenance of bridges; slope paving and erosion control; snow removal or snow fences; guide rails; traffic signs; sweeping of debris; care of trees and other vegetation.

References are made to other publications of the Asphalt Institute. These are available from the Asphalt Institute headquarters at the address below.

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CHAPTER 1

INTRODUCTION

A well designed and constructed asphalt pavement will provide a smooth riding surface, carry the expected loads, and require only routine maintenance for its design life. Pavements, if maintained in their as-constructed condition, would theoretically last forever. But in practice, maintenance helps the pavement perform satisfactorily during its designed life.

All pavements require maintenance, due to the effects of traffic and the environment on the exposed pavement materials. Maintenance not only preserves the pavement surface, but prevents accelerated wear. It should not be regarded as a temporary action, but as an investment in the pavement structure and insurance against costly pavement renovation.

Pavement maintenance is a major activity of every highway, street and airfield department. Maintenance money is often limited and maintenance personnel are called upon to "make one dollar do the work of two," not an easy task. Large differences in soil types, climate, terrain, traffic and other factors make for greatly varying problems, even within small areas. Some regions are rugged and mountainous while others are fairly smooth and level. Some have heavy rainfall others are semi-arid. Some highways and streets must accommodate vehicles carrying coal, ore, logs, or other heavy loads, while others are subjected to only light-weight traffic. Despite these differences, there are proven maintenance methods that work equally well in all regions. Presenting some of these methods is the purpose of this manual.

This is a how-to-do-it manual, limited to specific information on the use of asphalt in pavement maintenance and repair. Pavement management, including the planning, programming, financing and administration of maintenance, is beyond its scope. However, some information on these important topics may be found in the Asphalt Institute publications Asphalt Overlays for Highway and Street Rehabilitation (MS-17), A Pavement Rating System for Low-Volume Asphalt Roads (IS-169), and Alternatives in Pavement Maintenance, Rehabilitation and Reconstruction (IS-178).

Maintenance Policy

Pavement maintenance is not easy to define. Maintenance departments generally agree what it is but there are some minor differences. Some call pavement improvement "maintenance". Others include only the work that keeps the pavement in its as-constructed condition.

Taking all of these into consideration, the definition that seems to fit best is:

> Pavement maintenance is routine work performed to keep a pavement, under normal conditions of traffic and forces of nature, as nearly as possible in its as-constructed condition.

Maintenance activities can typically be separated into two categories: preventive maintenance, and corrective maintenance. Preventive maintenance would be those activities used to maintain the present condition and extend the service life of the pavement. Preventive maintenance may include seal coats, crack sealing, drainage maintenance, etc.

Corrective maintenance would be those activities used to remedy a pavement distress and maintain an acceptable pavement condition. Corrective maintenance may include patching and repairs, surface treatments, slurry seals, and thin overlays of less than 25mm (1 in.). (Some agencies may consider thin overlays rehabilitation.)

Glossary

Alligator Cracks–Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire.

Asphalt Concrete–High-quality, thoroughly-controlled hot mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted into a uniform dense mass. [See Model Construction Specifications for Asphalt Concrete and Other Plant-Mix Types (SS-1), Asphalt Institute.]

Asphalt Emulsion Slurry Seal–A mixture of slow-setting emulsified asphalt, water, aggregate and mineral filler, produced to a slurry consistency and placed on pavement surface. [See ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.]

Asphalt Fog Seal–A light application of slow-setting asphalt emulsion diluted with water. It is used to renew old asphalt surfaces and to seal small cracks and surface voids. [See ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.]

Asphalt Leveling Course–A layer of an asphalt aggregate mixture of variable thickness used to eliminate irregularities in the contour of an existing surface prior to placement of an overlay.

Asphalt Overlay–One or more courses of asphalt-aggregate mixtures placed on an existing pavement. The overlay generally includes a leveling course and/or pavement milling to correct the contour of the old pavement, followed by uniform course(s) to provide needed thickness.

Asphalt Pavements–Pavements consisting of a surface course of mineral aggregate coated and cemented together with asphalt cement, placed on supporting courses such as asphalt bases; crushed stone, slag, or gravel; or on portland cement concrete, brick, or block pavement.

Asphalt Prime Coat–An application of low-viscosity cutback to an absorbent surface, or a mixed-in application of emulsified asphalt. It is used only on an untreated base prior to placement of the asphalt pavement. [See ***Asphalt Surface Treatments-Construction Techniques (ES-11)***, Asphalt Institute.]

Asphalt Seal Coat–A thin asphalt surface treatment used to waterproof and improve the texture of an asphalt wearing surface. Depending on the purpose, seal coats may or may not be covered with aggregate. The main types of seal coats are fog seals, aggregate seals, slurry seals, and sand seals. [See ***Asphalt Surface Treatments-Construction Techniques (ES-12)***, and ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.]

Asphalt Surface Treatments–Applications of asphalt materials to any type of road or pavement surface, with or without a cover of mineral aggregate, that produce an increase in thickness of less than 25 mm (one inch). [See ***Asphalt Surface Treatments-Construction Techniques (ES-12)***, and ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.]

Asphalt Tack Coat–A very light application of asphalt applied to an existing asphalt or portland cement concrete surface, used to ensure a bond between the surface being paved and the overlying course. Asphalt emulsion diluted with water is the preferred asphalt material. [See ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.]

Bleeding or Flushing Asphalt–The upward movement of asphalt in an asphalt pavement resulting in the formation of a film of asphalt on the surface.

Blow-Up–The localized buckling or shattering of a rigid type pavement, occurring usually at transverse crack or joint.

Corrugations (Washboarding)–A form of plastic movement typified by ripples across the pavement surface.

Crack–Separation of the pavement due to natural causes, traffic action, or reflections from an underlying pavement.

Deflection–The downward vertical movement of a pavement surface due to the application of a load to the surface.

Depressions–Localized low areas of limited size that may or may not be accompanied by cracking.

Disintegration–The breaking up of a pavement surface from its original shape.

Fault–A difference in elevation of two slabs at a joint or crack.

Full-Depth Asphalt Pavement–An asphalt pavement structure that uses asphalt mixtures for all courses above the subgrade or improved subgrade. A Full-Depth asphalt pavement is laid directly on the prepared subgrade. [See *Thickness Design–Asphalt Pavements for Highways and Streets (MS-1)*, Asphalt Institute.]

Hot Mix Asphalt–High-quality, thoroughly-controlled hot mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted into a uniform dense mass. [See *Model Construction Specifications for Asphalt Concrete and Other Plant-Mix Types (SS-1)*, Asphalt Institute.]

Hydroplaning–The dangerous action of a vehicle being driven on a pavement over which a film of rain or other water has formed; on reaching certain speed, the vehicle's tires tend to ride upon the water surface rather than the pavement, drastically reducing the driver's control of the vehicle.

Micro-Surfacing–Micro-Surfacing is a mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water and other additives, properly proportioned, mixed and spread on a paved surface.

Mixed-in-Place (Road-Mix)–An asphalt course produced by mixing mineral aggregate and cutback or emulsified asphalt at the road site using travel plants, motor graders, or special road-mixing equipment.

Plant Mix–A mixture, produced in an asphalt mixing plant, consisting of mineral aggregate uniformly coated with asphalt binder.

Polished Aggregate–Aggregate particles in a pavement surface with edges that have been rounded and surfaces polished smooth by traffic.

Potholes–Bowl-shaped holes of varying sizes in the pavement, resulting from localized disintegration.

Pumping–Slab movement under passing loads resulting in the ejection of mixtures of water, sand, clay, and/or silt along transverse or longitudinal joints and cracks, and along pavement edges.

Raveling–The progressive separation of aggregate particles in a pavement from the surface downward or from the edges inward.

Recycling–The re-use, usually after some reprocessing, of a material that has already served its first intended purpose.

Reflection Cracks–Cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath.

Rutting–Channelized depressions that may develop in the wheel tracks of an asphalt pavement.

Scaling–The peeling away or disintegrating of the surface of portland cement concrete.

Shoving–A form of plastic movement resulting in localized bulging of the pavement.

Skid Hazard–Any condition that might contribute to making a pavement slippery.

Slippage Cracks–Cracks, sometimes crescent-shaped, that point in the direction of the thrust of the wheels on the pavement surface, caused by lack of bond between two pavement layers.

Spalling–The breaking or chipping of pavement at joints, cracks, or edges, usually resulting in fragments with feather edges.

Undersealing Asphalt–A high softening point asphalt used to fill cavities beneath portland cement concrete slabs and occasionally to correct the vertical alignment by raising individual slabs.

Upheaval–The localized upward displacement of a pavement due to swelling of the subgrade or some portion of the pavement structure.

Important Maintenance Considerations

➤➤ Pavement Inspections

Stresses that produce minor defects are constantly working in all pavements. These stresses may be caused by changes in temperature or moisture content, by traffic, or by small movements in the underlying or adjacent earth. Cracks, holes, depressions, and other types of distress are the visible evidence of pavement wear.

Early detection and repair of minor defects is, without doubt, the most important work done by the maintenance crew. Cracks and other surface breaks in their first stages are almost unnoticeable, and they may develop into serious defects if not repaired early. For this reason, qualified inspectors should make frequent, close inspections of the pavement. Indeed, this measure is necessary for effective use of maintenance money.

An inspection made from a moving vehicle, even one barely moving, is usually not close enough to detect areas where distress may begin. Cracks or other surface defects are often so small that only a person on foot can spot them. There are other small signs, such as mud or water on the pavement or shoulder, that may signal future trouble to an experienced observer. It is best to walk the pavement for close inspection or, at a minimum, inspect selected stretches of roadway.

Upon detection of the warning signs, make the required investigation to determine the cause of the distress and make the proper repair. If the pavement shows indications of structural problems, make deflection measurements to determine the extent of the affected area. [See the Asphalt Institute publication, *Asphalt Overlays for Highway and Street Rehabilitation (MS-17)*.]

➤➤ Drainage

Good drainage is absolutely essential for satisfactory pavement performance and long term trouble free service. The accumulation of excess water in the base or subgrade under a pavement surface may cause surface damage such as alligator cracking and upheaval. Moisture problems will not go away by filling cracks or placing skin patches. The source of the problem must be identified and eliminated.

One form of preventive maintenance is the seasonal inspection and cleaning of drainage systems. Properly working drains can eliminate some of the major causes of pavement damage. Each inspection should include all surface drainage structures, ditches and channels. Immediately clean out any clogged part of the system.

Examine subsurface drains to make sure they are working properly. The abnormal appearance of water on the pavement surface may indicate improperly located, incorrectly designed, or clogged subsurface drains. All drain outlets should be well marked on the ground and on maintenance maps, so they will not be overlooked on inspection trips.

Most subgrade soils consist of very fine materials (silt and clay) that weaken when wet. Therefore, when the subgrade is not properly shaped and sloped for drainage at the time of construction, water may collect on its surface and beneath the pavement layers, causing it to lose its stability and supportive strength. Under the action of traffic the wet soil may be churned into a mud slurry, and this will push up into the voids of aggregate base courses, destroying grain-to-grain interlock.

Drainage that lowers the water table prevents the accumulation of water from below the pavement and eliminates any accumulation formed by vapor or capillary action. Drainage will also minimize subgrade water that is slow to evaporate and may remain even in dry weather. Drainage will aid in preventing pockets of porous material from becoming subterranean reservoirs. Detailed information about pavement drainage is contained in the Asphalt Institute publication, *Drainage of Asphalt Pavement Structures (MS-15)*.

➤➤ Moisture and Granular Bases

Many asphalt pavements consist of an asphalt surface over a granular base. The base materials range from gravel and pit-run products to crushed and processed rock. These bases serve well as long as they are properly drained. But if they become saturated with water they lose strength rapidly under the weight and action of traffic.

Saturation of granular bases is the cause of many maintenance problems. Asphalt-surfaced pavements on granular bases may become soft and crack in the familiar alligator or chicken-wire pattern. These problems won't disappear by filling cracks or placing skin patches. The cause of the distress should be eliminated. Some high-volume pavements with granular bases are designed with drainage systems to prevent saturation by ground or surface water. But there are many thousands of miles of sand-clay-gravel roads, now surfaced with asphalt, that become saturated and cause pavement distress. Usually these roads have a high percentage of plastic fine material in

them as binder, needed to hold the materials in place when the surface was unpaved. As sand-clay-gravel roads, they become saturated when it rains and dry out rapidly because moisture was free to evaporate. With the addition of the impervious asphalt pavement, evaporation through the surface is blocked. The water then migrates into the base materials from the shoulders and from the subgrade and the sand-clay-gravel loses strength as it becomes soaked. Cracking, heaving, and other forms of distress take place. Also, in its weakened condition the base, unable to support the traffic, deflects more than normal and cracking is intensified.

Therefore, when investigating surface failures that appear to be related to excessive deflection, the base should be checked for plastic fines or trapped water. The repair may require digging out the broken area to sound material, improving drainage, and patching with asphalt patching mixture.

➤➤ Prompt and Proper Repairs

Make repairs as soon as possible after their need is discovered. The true cause(s) of the pavement distress must first be determined. Repairs can then be made to correct the cause of the distress and prevent or retard its reoccurrence. This is particularly important when the defect makes driving hazardous.

Weather conditions often make temporary repairs necessary to prevent further damage until more permanent repairs can be made. Selecting the best time to make repairs involves the careful balancing of several things, and requires both experience and judgment. Be careful not to allow temporary repairs to become permanent repairs. The problem is time–make sure to take the time to do a permanent repair. Time and money spent for such repairs are good investments because the same repairs are not made repeatedly.

➤➤ Street Maintenance

Streets and urban roads can develop any of the distresses discussed in Chapters 3 and 4. However, some of these distresses are a bigger problem in streets than in other classes of pavement. For example, shoving and corrugating of asphalt pavement surfaces show up more often in urban areas. This is due to limited speeds on steep grades, frequent traffic lights and stop signs that multiply the need for braking.

A problem almost exclusive to urban areas is utility cuts in the pavement. Although repairs are controlled by municipal specifications, backfilled trenches may settle and require corrective maintenance. Specifying high-quality materials and adequate compaction of all the materials will result in permanent utility cuts repairs. In growing urban areas, streets may become scarred from many cuts and patches for utility connections. Many cities have found that a thin hot-mix overlay, a surface treatment or stage construction are economical and effective treatments for these conditions.

Because traffic control is usually more of a problem in urban areas than in rural areas, street maintenance must be done quickly and efficiently for the least interference between traffic and maintenance personnel. Each city has its own special problems connected with traffic control and must solve them individually. The common goal is to minimum disruption of traffic flow while providing maximum safety for the public and maintenance crew.

➤➤ Maintenance Personnel

Maintenance work requires proper supervision, skilled workers, and good workmanship. Unless all three are used, some repairs will perform poorly and need repeating. Since most pavement repairs involve asphalt, a thorough knowledge of this material is essential for maintenance personnel. This is especially true for supervisors and inspectors. Successful pavement maintenance requires a knowledge of what asphalt materials are available and how to use them (See Chapter 2). The basic skills needed for pavement maintenance can be acquired through work experience, and a close study of Asphalt Institute publications will provide an understanding of the principles of pavement design and how pavement materials behave. Publications recommended for maintenance personnel include:

Thickness Design–Asphalt Pavements for Highways and Streets (MS-1).
Asphalt Surface Treatments-Construction Techniques (ES- 12).
Asphalt Cold Mix Manual (MS-14).
Drainage of Asphalt Pavement Structures (MS-15).
A Basic Asphalt Emulsion Manual (MS-19).
Factors Affecting Compaction (ES-9).
Alternatives In Pavement Maintenance, Rehabilitation, and Reconstruction (IS-178).
Asphalt Overlays for Highway and Street Rehabilitation (MS-17).

➤➤ Maintenance Equipment

The tools and equipment provided for maintenance activities are as important as the personnel. Maintenance personnel cannot be expected to construct effective maintenance treatments without equipment designed to

perform the activities. There are many types and models of equipment, from hand tools to compaction equipment, that can be used to perform maintenance functions correctly. There are also many inappropriate devices substituted in an attempt to perform maintenance activities. Proper equipment handled by properly trained personnel will go a long way toward producing long lasting maintenance treatments.

➤➤ *Weather*

Proper weather conditions are essential for the long term performance of maintenance repairs. For example, crack filling is most successful during periods of cool, dry weather; patches adhere best when the pavement is warm and dry; and seal coats and other surface treatments require warm and dry weather for best results. A phone call to the weather bureau may help in scheduling maintenance work during uncertain weather.

While repairs can be made during cold or damp weather, much greater care is needed during such periods or repairs are less likely to be satisfactory. It is best to make the repairs when the safety and comfort of the traveling public are concerned, even though they may be only temporary.

Patching and resurfacing work should be done during warm [10°C (50°F) and above] and dry weather. When hot or warm mixtures are placed on cold pavements, they may cool so fast that adequate compaction is difficult. This cooling effect is increased when the mixture is placed in thin layers. Moreover, asphalt and asphalt mixtures usually do not bond well to damp surfaces. [See the Asphalt Institute publication, *Factors Affecting Compaction (ES-9)*.]

Mixtures containing emulsified or cutback asphalt are slow in curing when humidity is high. This is because the air already contains a large amount of water vapor and doesn't readily allow the water or solvent to evaporate. Low temperatures also retard evaporation.

Seal coats and other surface treatments can be affected by moisture during the first few hours after their placement. Rain and/or fast traffic during this critical period may often result in the loss of the cover aggregate.

➤➤ *Safety*

An important contribution to high-quality maintenance is an active safety program. For maintenance people, safety measures reduce the fear of injury, and allow greater peace of mind in performing tasks. This results in quality work.

For the safety of the workers, motorists must be warned about what is going on ahead and what must be done when passing through the work area. Signs and warning devices should be placed far enough ahead for the motorist to grasp their meaning, but not be so far ahead that they lose their meaning. A sign indicating the end of the work area is also desirable. Use flagmen near the work when sight distance is restricted or dangerous driving conditions exist. An appropriate traffic control reference is the ***Manual on Uniform Traffic Control Devices for Highway and Streets***, from the Federal Highway Administration, U.S. Department of Transportation.

The kind of safety equipment required for maintenance personnel depends on the type of work being done. As appropriate, members of the maintenance crew should be furnished with vests, hard hats, goggles, gloves with gauntlets, hearing protection and any other safety apparel that will reduce the possibility of accidents or injury.

CHAPTER 2

ASPHALT MAINTENANCE MATERIALS

Various asphalt materials and asphalt mixtures can be successfully used for pavement maintenance activities. This chapter describes these materials and their qualities. Maintenance practices involving these materials are described in Chapter 3 and 4.

Asphalt Materials

Asphalt is refined from crude oil and is a product of the petroleum industry. At ambient temperatures, it is solid or semi-solid. To be used in maintenance operations, it must be made liquid enough to coat the aggregate. This is accomplished in three different ways: by heating, as in a heating kettle or storage tank (asphalt cement); by dissolving in a petroleum solvent (cutback asphalt); by combination with water (asphalt emulsion). Table 2.1 summarizes the various uses of asphalt materials. See *Introduction to Asphalt, (MS-5)*, Asphalt Institute, for more detailed information.

➤➤ Asphalt Cement

Asphalt cement is the basic material of the asphalt family. It is a semisolid material used in making hot mix asphalt, and for surface treatments, seal coats, and crack filling. Various grading systems are used to specify asphalt cement by its hardness, viscosity, and desired performance characteristics. Additives and/or modifiers can be combined with asphalt cement to change its properties.

➤➤ Cutback Asphalt

Asphalts that are liquefied by blending with petroleum solvents are referred to as "cutbacks." When they are spread on the road or pavement, the solvent evaporates, leaving the asphalt cement behind. These asphalts are made according to curing time: rapid-curing (RC), containing a naphtha-like solvent, and medium-curing (MC), with a solvent similar to kerosene. A third type, slow-curing (SC), is usually not called a cutback because its solvent, somewhat like heavy fuel oil, is not added but left in during the refining process. The SC type also is sometimes referred to as "road oil."

Table 2.1 Guide for Uses of Asphalt

Type of Construction	Asphalt Cements														
	Viscosity Graded -Original					Viscosity Graded -Residue					Penetration Graded				
	AC-40	AC-20	AC-10	AC-5	AC-2.5	AR-16000	AR-8000	AR-4000	AR-2000	AR-1000	40-50	60-70	85-100	120-150	200-300
Asphalt-Aggregate Mixtures															
Asphalt Concrete and Hot Laid Plant Mix															
Pavement Base and Surfaces															
Highways	X	X	X	X	X[7]	X	X	X	X	X[7]	X	X	X	X	X[7]
Airports		X	X	X			X	X				X	X	X	
Parking Areas	X	X	X			X	X	X			X	X	X		
Driveways		X	X				X	X				X	X		
Curbs		X					X					X			
Industrial Floors	X	X				X	X				X	X			
Blocks	X					X					X				
Groins	X	X				X	X				X	X			
Dam Facings	X	X				X	X				X	X			
Canal and Reservoir	X	X				X	X				X	X			
Cold-Laid Plant Mix[10]															
Pavement Base and Surfaces															
Open-Graded Aggregate															
Well-Graded Aggregate															
Patching, Immediate Use															
Patching, Stockpile															
Mixed-in-Place (Road Mix)[10]															
Pavement Base and Surfaces															
Open-Graded Aggregate															
Well-Graded Aggregate															
Sand					X										X
Sandy Soil					X										X
Patching, Immediate Use															
Patching, Stockpile															
Recycling															
Hot-Mix			X	X	X			X	X	X			X	X	X
Cold-Mix[10]					X					X					X
Asphalt-Aggregate Applications															
Surface Treatments															
Single Surface Treatment				X	X									X	X
Multiple Surface Treatment				X	X									X	X
Aggregate Seal				X	X				X					X	X
Sand Seal															
Slurry Seal															
Asphalt Applications															
Surface Treatments															
Fog Seal															
Prime Coat															
Tack Coat															
Dust Laying															
Mulch															
Membrane															
Canal and Reservoir Linings	X										X				
Embankment Envelopes	X	X				X	X				X	X			
Crack Filling															
Asphalt Pavements															
Portland Cement Concrete Pavements	X[4]					X[4]					X[4]				

[1]Mixed-in Prime Only
[2]Diluted with water
[3]Slurry mix
[4]Rubber asphalt compounds
[5]Diluted with water by the manufacturer
[6]MS-2 only
[7]For use in cold climates

Table 2.1 Guide for Uses of Asphalt

Emulsified Asphalts															Cutback-Asphalts								
Anionic									Cationic						Medium Curing (MC)[8]					Slow Curing (SC)			
RS-1	RS-2	MS-1, HFMS-1	MS-2, HFMS-2	MS-2h, HFMS-2h	HFMS-2s	SS-1	SS-1h	CRS-1	CRS-2	CMS-2	CMS-2h	CSS-1	CSS-1h	30	70	250	800	3000	70	250	800	3000

Each type is available in four viscosity-controlled grades ranging from Grade 70, which contains the most solvent and is the most fluid, to Grade 3000, which contains the least solvent and is the least fluid (slowest pouring). A special grade (MC-30) is included in the medium-curing type and is used almost exclusively for prime coating and dust laying. RC materials are generally no longer used due to energy and environmental concerns.

➤➤ *Asphalt Emulsion*

Asphalt emulsions are liquid mixtures of asphalt cement, water, and an emulsifying agent. In an asphalt emulsion, minute globules of asphalt are suspended in water by using an emulsifying agent. Asphalt emulsions are graded according to the time it takes for them to "break" or come out of suspension, and are referred to as rapid-setting (RS), medium-setting (MS), slow-setting (SS). Proprietary quick-setting (QS) emulsions are also available. Asphalt emulsion usually has a dark brown color when the asphalt is in suspension that becomes black when the asphalt and water separate.

Asphalt emulsions come in two types: anionic and cationic. In the anionic type, the globules of asphalt have a negative electrical charge. In the cationic type, the globules are positively charged. These differences in electrical charge improve the coating and bonding properties of the emulsion when used with aggregates having oppositely charged surfaces.

As in the cutback grades, the lower numbered grades are the most fluid (Grade 1 is more fluid than Grade 2). The small letter h indicates that the base asphalt is a somewhat harder grade. The letter C indicates a cationic emulsion. HF is the designation for high float emulsions.

Asphalt Materials in Pavement Maintenance

➤➤ *Prime Coats*

Priming is the spraying of asphalt on the surface of a non-asphalt base course. If the base of a deep patch is made with untreated material it should be primed with a cutback asphalt or penetrating prime asphalt emulsion. Priming the base will help waterproof the surface of the base, plug capillary voids, coat and bond loose mineral particles, harden or toughen the surface, stabilize and maintain the base to ensure a patch of maximum efficiency, promote adhesion between the base and asphalt patching material.

From 0.9 to 2.3 liters/m² (0.2 to 0.5 gal/yd²) of low viscosity MC cutback asphalt is sprayed on the prepared surface of the base and allowed to penetrate as far as possible. If spray equipment is not available, hand methods can be used to apply the prime. Care must be taken not to apply excess asphalt. The asphalt material used to prime the base should only knit together the top particles. The cutback asphalt should be given time to penetrate and cure before the patch mix is placed.

The lower viscosity of the 30 and 70 grade cutback asphalts makes them better adapted for use on fine-grained, dense bases. The higher viscosity of the 250 grade cutback asphalt is desirable for open-textured, porous bases. If MC cutback is not available, SS-1, CSS-1, SS-lh, CSS-lh, MS-2, or CMS-2 emulsified asphalt may be used as a mixed-in-prime, either on the road or at the source of the base aggregate. The application rate is normally 0.5 to 1.4 liters/m² (0.1 to 0.3 gal./yd²) of emulsion per 25mm (1 in.) of depth. Proprietary penetrating asphalt emulsion prime materials are also available. If an emulsion is used for priming, the emulsion should "break" and most of the water allowed to evaporate before the patching mixture is placed.

➤➤ *Tack Coats*

As its name implies, the purpose of a tack coat is to provide a bond between an existing pavement and a course that is to be placed over it. The tack coat material is not expected to penetrate into the pavement, and for this reason the application should be very light. In maintenance activities, a tack coat is applied to the asphalt surface before placing a surface patch or thin overlay. Also, the prepared edges of the surface surrounding an area being patched should be tack coated to ensure a good bond between the edges and the patch material.

Asphalt emulsions SS-1, SS-lh, CSS-l, and CSS-lh are often used for tack coats. Because they can be effectively diluted with clean fresh water, the emulsion is thinned with an equal amount of water to help ensure a light application. The tack coat is applied at the rate of 0.25 to 0.7 liters/m² (0.05 to 0.15 gal./yd²) of diluted asphalt emulsion.

The use of pneumatic-tired rollers on a freshly applied, ***non-uniform*** tack coat will aid in obtaining uniformity of coverage. It will also minimize the possibility of localized areas of excess tack that may later become a slip plane or cause bleeding in the pavement surface.

After application of the tack coat, allow the emulsion to break and the water to evaporate before placing the patching mixture or overlay. Traffic should be kept off of the tacked area when possible. See ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.

➤➤ Crack Sealants

Many types of asphalt crack sealing materials are available. However, certain properties apply to any material used for crack sealing, including:

- Good bonding/adhesion
- Flexibility and elasticity
- Ease of application
- Resistance to softening
- Resistance to tracking
- Resistance to aging and weathering
- Compatibility to asphalt

Emulsified and cutback asphalts have limited flexibility and, therefore, maintain a tightly sealed crack only as long as crack movement is minimal. Once expansion and contraction or excessive vertical movement of the crack occurs, either under traffic or environmental forces, the effectiveness of the seal can be lost. In many areas, such as climates with large temperature changes, these may considered temporary cracking sealing materials.

Modified asphalt materials and specially prepared crack sealing materials (those meeting ASTM Specification D1190, D3405, or D5078, or AASHTO Specification M173) are generally used for more "permanent" crack sealing. Good crack preparation and controlled handling techniques are required to achieve good performance from these materials.

➤➤ Seal Coats

A seal coat is a thin asphalt surface treatment. It is usually a single application of an asphalt material that may or may not be covered or combined with aggregate. Seal coats are appropriate in the maintenance of surface distresses. Seal coats do not increase structural strength of a pavement section, nor are they appropriate for repairing structural problems such as alligator cracking. They are usually considered a preventive maintenance treatment.

The principal types and uses of seal coats in pavement maintenance are briefly described here. See *A Basic Asphalt Emulsion Manual (MS-19)*, Asphalt Institute, for complete design and construction information on seal coats.

Fog Seal. A fog seal is a light application of emulsified asphalt, usually without aggregate cover. It is used to renew asphalt surfaces that have become dry and embrittled with age, to seal small cracks and surface voids, and to coat surface aggregate particles to reduce raveling.

Slow-setting asphalt emulsions SS-1, SS-lh, CSS-1, and CSS-lh, diluted with clean water, generally are used for fog seals. The emulsion is usually diluted with an equal amount of water and sprayed at the rate of 0.45 to 0.7 litre/m² (0.1 to 0.15 gal/yd²) of diluted material. Exact quantities depend on the surface texture, and degree of dryness and amount of cracking of the pavement being fog sealed. Over-application must be avoided as this may result in asphalt pick-up by vehicles or a slippery surface.

Slurry Seals. A slurry seal is a mixture of slow-setting asphalt emulsion, fine aggregate, mineral filler, and water that can be used in both preventive and corrective maintenance activities. These materials are usually combined in special machines designed for mixing and placement of slurry seals. A slurry seal will seal surface cracks, stop raveling and loss of matrix, make open surfaces impermeable to air and water, and improve skid resistance. Its timely application will help reduce surface distress caused by oxidation of the asphalt and embrittlement of the paving mixture.

The mixture is prepared in the form of a creamy-textured slurry and is applied in an average thickness of 3 to 6 mm (1/8 to 1/4 in.). The predetermined quantities of the slurry are combined in a traveling, continuous-flow mixing machine (Figure 2.1). The mixture is discharged onto the pavement in front of an attached spreader box that spreads the slurry by squeegee-type action. Slow-setting asphalt emulsions SS-1, SS-lh, CSS-1, and CSS-lh and proprietary quick setting emulsions are used in the slurry mix, and three generally-accepted aggregate gradations and maximum aggregate sizes can be used depending on the texture of the existing pavement.

Micro-Surfacing. Micro-Surfacing is a mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water and other additives, properly proportioned, mixed and spread on a paved surface much like a slurry seal. Micro-Surfacing is made with a quick-set polymer modified CSS-1h asphalt emulsion. It provides restorative qualities similar to slurry seals, with additional qualities such as higher resistance to abrasion that are provided by the modified asphalt.

Surface Treatments (Chip Seals). Surface treatment is a broad term describing a sprayed asphalt that is immediately covered with aggregate and rolled (Figure 2.2). Types and names of surface treatments include sand seals, chip seals, single and double surface treatments, and cape seals.

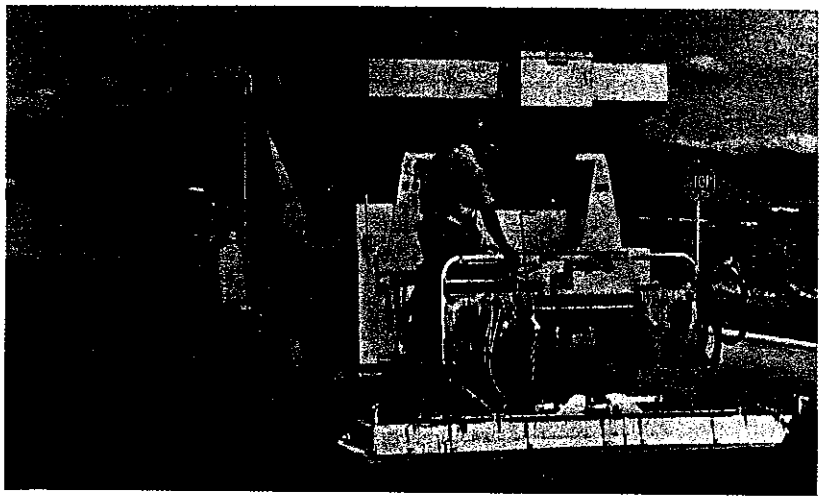

Figure 2.1 Slurry Seal Machine

Properly constructed surface treatments are economical, easy to place, and long lasting. They provide skid resistance, a waterproof cover over the underlying structure, and can restore an older, weathered pavement surface.

The asphalt commonly used is a rapid setting (RS or CRS) asphalt emulsion. The choice of asphalt depends on the cover aggregate, the availability of equipment and materials, the weather, and the experience of the maintenance crew. See *A Basic Asphalt Emulsion Manual (MS-19)*, Asphalt Institute.

➤➤ Patching Mixtures

The major cost of patching lies in preparing and placing the patch, not in the cost of the material. Therefore, it is economical to use high quality materials with proper repair procedures to make patches last. High-quality, hot-mixed patching mixtures make long-lasting patches that develop stability rapidly. They should be used whenever practical and economical. An economic evaluation that investigates pavement repair procedures and materials will help determine the cost effectiveness of specific repair operations.

Many patches bleed, become unstable, and are subject to pushing after placement. The cause is usually an unstable mix or an excess of asphalt in the patching mixture. When a stockpiled patching mixture is used, patch instability can also be caused by not allowing the patch to cure before subjecting it to traffic. For the best patching mixture a laboratory investigation should be made of the materials proposed for use (see Chapter 5 for guidelines).

The following paragraphs describe, in a general way, the most common types of asphalt mixtures used in maintenance operations. There are obviously other mix compositions that have successful service histories in various localities. These should be used when they are available.

Figure 2.2 Surface Treatment Operation

Hot Mix Asphalt. This is a high quality, thoroughly controlled hot mixture of well-graded, high quality aggregate and asphalt cement. The materials are mixed at a high temperature and should be laid and compacted before the mix temperature drops much below 85°C (185°F). These mixtures are designed for strength and long life. When it is practical and economical to do so, preference should be given to their use. See *Model Construction Specifications for Asphalt Concrete and Other Plant Mix Types, Specification Series No.1 (SS-1)*, Asphalt Institute, for complete details of these mixes.

Plant Mixes with Cutback or Emulsified Asphalts, Cold Laid. These mixtures consist of an aggregate and a cutback or emulsified asphalt mixed in a plant. They may be used immediately, if properly aerated,

or stockpiled for future use. The mixtures may or may not be controlled with the same precision as required for hot mix asphalt. For details of these mixtures, refer to Chapter 5. Improved patch performance may be realized using a modified asphalt material.

Road Mixes with Emulsified or Cutback Asphalts. These mixtures are usually local mineral aggregates road mixed on a suitable mixing platform, with either asphalt emulsions, or medium or slow-curing cutback asphalt. The mixtures are normally stockpiled for future use. The completed mixture should be stockpiled in a well-drained, accessible location. The stockpile should be carefully shaped to shed rainwater and prevent saturation of the mix. For details on the design of stockpile patching mixtures see Chapter 5.

Asphalt pavement maintenance as discussed here applies to all asphalt pavement structures, from deep strength asphalt to surface treatments to asphalt overlays. It applies to the traveling lanes and shoulders of highways and streets, to runways and taxiways, to parking lots, aprons and driveways.

This chapter contains a description of the typical asphalt pavement distresses. For each distress type, the most common cause of the distress is discussed, and maintenance options are suggested assuming that this distress type is not occurring in conjunction with other distress types. This does not suggest that the topic is completely covered. There are distresses that cannot be categorized, and there are good methods of repair that are not described here.

Maintenance procedures for correcting distresses in asphalt pavements include patching, crack sealing, surface treatments, and in some cases resurfacing. There are customary maintenance and repair procedures that have proven effective in producing neat, long-lasting repairs, and these procedures are referred to when discussing options for pavement distresses.

Crack Sealing

Cracks are sealed for two primary reasons:

- to prevent intrusion of incompressible materials into the crack
- to prevent intrusion of water into the underlying pavement layers

Along with proper drainage, crack sealing is probably the single most important maintenance procedure. Many distresses can be related to water infiltration. If the water is kept out of the pavement system, there is a good chance distresses will not develop.

The distresses repaired by sealing individual cracks are longitudinal, transverse and diagonal cracks, edge cracks, reflective cracks, construction joint cracks, widening cracks, and edge or lane joint cracks.

These are general guidelines for crack sealing procedures and may vary according to local policy:

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These are general guidelines for crack sealing procedures and may vary according to local policy:

- ***Hairline cracks,*** less than 6 mm (1/4 in.) in width, are too small to fill effectively. Because of this, nothing is usually done unless they cover much of an area. If there are many hairline cracks in an area then a surface treatment such as a slurry seal or chip seal may be appropriate. The surface treatment selected must be fluid enough to flow into the hairline cracks.
- ***Small cracks,*** 6 to 20 mm (1/4 to 3/4 in.) in width, are usually routed to about 3 mm (1/8 in.) greater than the average width of the crack, and then cleaned and sealed. Routing provides a good sealant reservoir and reduces raveling potential. If the cracks are over 20 mm (3/4 in.) deep, a "backer rod" is often installed to conserve sealant.
- ***Medium cracks,*** 20 to 25 mm (3/4 to 1 in.) wide, usually require only cleaning and sealing, with a backer rod installed for cracks over 20 mm (3/4 in.) deep.
- ***Large cracks,*** greater that 25 mm (1 in.) wide, should filled with an asphalt emulsion slurry or fine graded hot mix asphalt.
- Medium and large cracks with ***severe spalling*** may require repair with a patch.

Crack Sealing Procedures

If needed, rout out the crack to the sealant manufacturers' specifications for width to depth ratio. Clean the crack using high pressure air, sandblasting, wirebrushing, hot airblasting (Figure 3.1), or high pressure water. This is a key step to crack sealing or filling. If the crack is not thoroughly cleaned the sealant will not adhere to the sides. Sandblasting, although the best at cleaning, is the most labor intensive. Hot airblasting is done using a hot compressed-air (HCA) lance, or heat lance, connected to an air compressor. This method helps dry the crack and if the sealing operation closely follows the hot air drying, the heated crack surface helps the sealant adhere to the crack. The hot air lance produces super heated air and will burn the crack surface if left in one place too long. If high pressure water is used the crack must be thoroughly dried before sealing.

After removing the old sealant and/or cleaning the cracks, check them for depth. Generally if they are over 20 mm (3/4 in.) deep a backer rod is used to conserve sealant (Figure 3.2). The backer rod should be a compressible, non-shrinking, non-absorbent material with a melting point

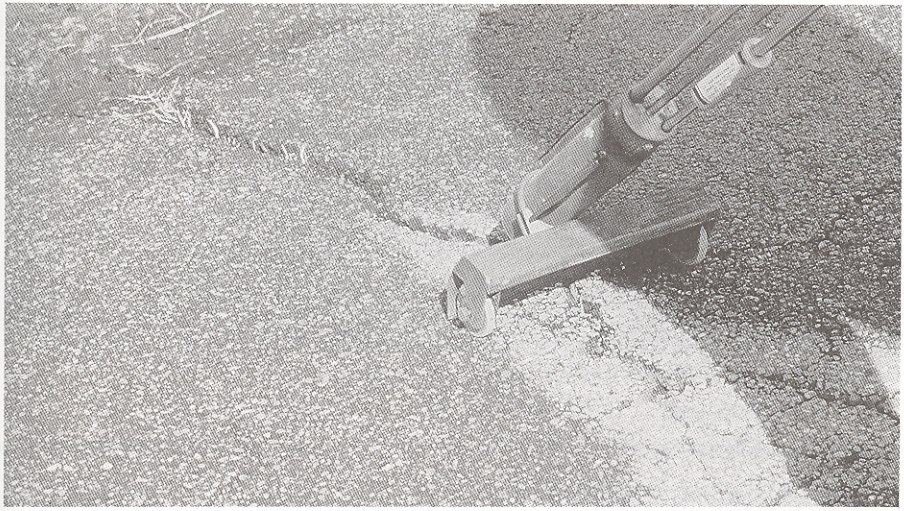


Figure 3.1 Hot Airblasting

higher than the sealant temperature. The backer rod should be about 25% wider than the crack so it doesn't slip down, or float out after installing the sealant.

Immediately before applying the sealant inspect the cracks to ensure they are clean, dry and any backer material is properly installed. If the cracks have been left unsealed for any period of time, clean them out with compressed air before sealing them.

Figure 3.2 Backer Rod Installation

The sealant should be applies from the bottom to the top of the crack to prevent air bubbles from forming and creating a weak spot in the sealant. It is desirable to use a sealant kettle that has an injection wand for the best results (Figure 3.3). To prevent tracking the sealant should be left about 3 to 6 mm (1/8 to 1/4 in.) below the top of the crack. Use a squeegee to remove any excess sealant on the pavement surface (Figure 3.4).

Seal Coats

There are many types of seal coats that are effective preventive maintenance methods when used properly. The typical seals used for maintenance include:

- Fog Seal
- Slurry Seal
- Surface Treatment (Chip Seal)
- Sand Seal
- Micro-Surfacing

Seal coats are appropriate for various distresses, including: large areas with a high density of small cracks; weathering/raveling; stripping; polished aggregate; segregated areas; and block cracking. Surface seals can be used as a temporary repair for alligator cracking if there is no base failure. Asphalt materials used in seal coats are given in Chapter 2. For detailed information on surface treatments, see ***A Basic Asphalt Emulsion Manual (MS-19)***, Asphalt Institute.

Figure 3.3 Sealant Kettle With Injection Wand

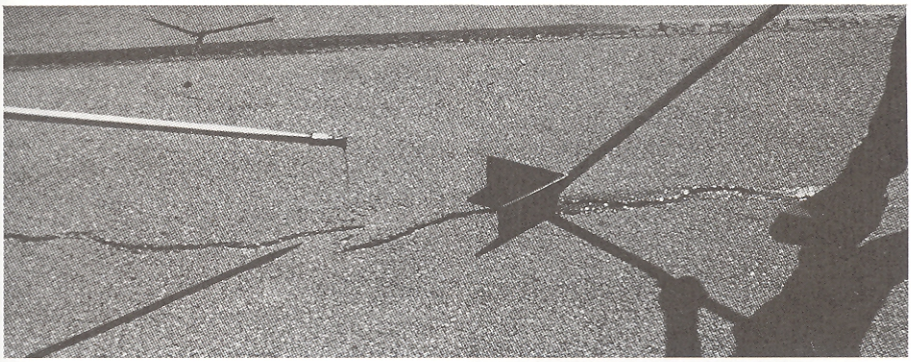


Figure 3.4 Squeegee

Patching

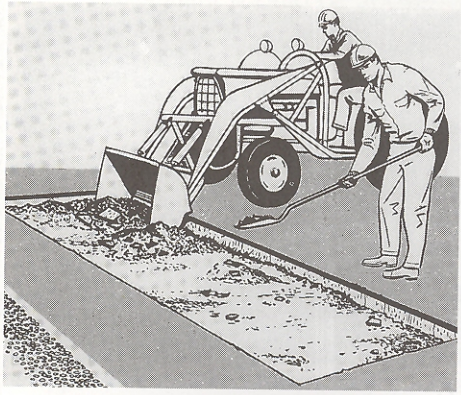
Many studies have been conducted comparing patching procedures. Variables have included material types (e.g. hot mix asphalt, cold mix asphalt, modified asphalt cold mixes); material installation techniques (e.g. "throw-and-go," full depth repairs); and equipment (e.g. pavement saws, mixture heaters, compactors). Agencies have had various degrees of success with specific patching procedures. Other variables, such as weather and emergency repair needs, enter into the decision process on which procedure to use. Ideally, a life cycle cost analysis of repair procedures and materials is conducted to evaluate the cost effectiveness of specific repair operations.

Patches are appropriate for repairing such distresses as alligator cracking; potholes; failed patches or utility cuts; heaves or swells; corrugations, washboarding, or shoving; depressions; slippage cracks; and rutting. Typically, a full depth patch is considered a permanent repair, while a skin patch will provide temporary relief from the distress.

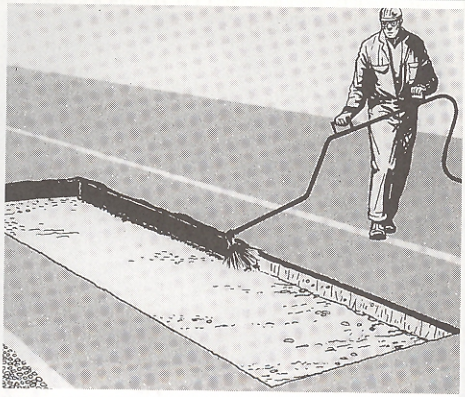
➤➤ Full Depth Patching

Simply stated, this patching procedure removes the material in the failed area and replaces it with fresh asphalt mix. Although the operation is not difficult, some of the necessary fine points are often not attended to. Yet, these fine points often determine whether the completed patch will be a temporary expedient or an integral part of a functional pavement system. Figure 3.5 illustrates the full depth patching procedures.

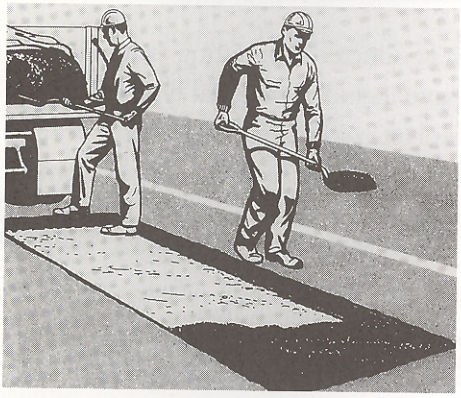
Mark the area to be patched, extending at least 0.3 m (1 ft) outside of the distressed area. The outline should be rectangular with two of the sides at



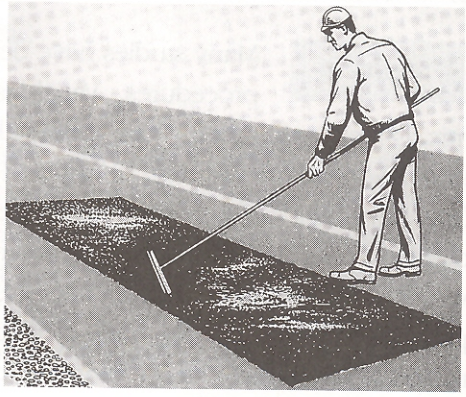
Removing Surface & Base



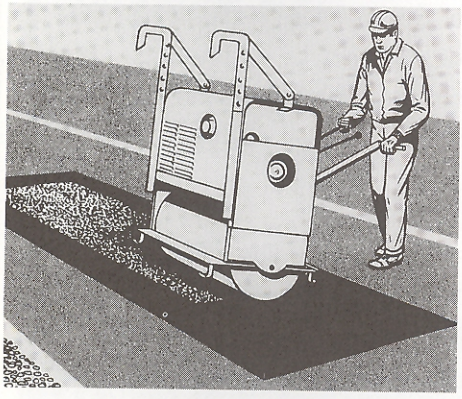
Applying Tack Coat



Backfilling Hole with Plant Mix



Spreading the Mix



Compacting the Mix

Straightedging the Patch

Figure 3.5 Full Depth Patching Procedures

right angles to the direction of traffic. Cut the outline of the patch with a pavement saw or pneumatic hammer.

Excavate as much pavement as necessary, including granular base and subgrade, to reach firm support. For the patch to be an integral part of the pavement, its foundation must be at least as strong as the original pavement. Appropriate excavation equipment includes milling machines, back hoes, and front end loaders. For a distress such as slippage cracking, milling of the affected asphalt course may be the only excavation necessary. For alligator cracking, it may be necessary to remove weak granular base or subgrade materials. Drainage installation and/or maintenance may also be necessary to correct base and/or subgrade problems.

The faces of the excavation should be straight, vertical, and solid. Trim and compact the granular base or subgrade to establish a firm foundation. Apply a tack coat to the vertical edges of the excavation and a prime or tack coat to the base of the excavation.

Backfill the excavation with asphalt mixture. Shovel the patching mixture directly from the truck, and place the mixture against the edges first. Spread the mixture carefully to avoid segregation. Avoid pulling material from the center of the patch to the edges. If more material is needed at the edge, it should be deposited there and any excess raked away. The quantity of material used should be enough to ensure that, after compaction, the patch surface is flush with the adjacent pavement, not humped or depressed. The maximum lift thickness depends upon the type of asphalt mixture and the available compaction equipment. Hot asphalt mixtures should be placed in lifts as thick as practical, to increase heat retention and facilitate compaction.

From a compaction standpoint, hot mix asphalt patches can be backfilled in one lift. However, when placing a patch deeper than 125 mm (5 in.), it is often useful to leave the first lift 25 to 50 mm (1 to 2 in.) below the finished grade, making it easier to judge the total quantity of mixture required for the patch. Patches constructed with cold mix materials must be placed in layers thin enough to allow evaporation of the diluents that make the mixture workable.

Compact each lift of the patch thoroughly. The type of equipment will depend on the size of patch. A vibratory plate compactor may be sufficient for small patches, while a vibratory compactor is more effective for larger areas, and will be necessary for thicker lifts. For the patch surface, compact the edges first, overlapping 150 mm (6 in.) onto the edge of the patch. Continue compaction from the low side to the high side, with each pass lapping an

additional 150 mm (6 in.) onto the uncompacted material.

After compacting, the surface of the patch should be at the same grade as the surrounding pavement. Check the vertical alignment and smoothness of the patch with a straight-edge. Some agencies seal around the edges of the completed patch with an appropriate joint sealant material, to give added protection against water infiltration.

➤➤ *Surface Patch (Skin Patch)*

This is usually a temporary repair and should be used only on pavements of at least 100 mm (4 in.) thick. It can be used to repair slippage cracking; minor rutting or corrugations; depressions; raveling; and alligator cracking. A surface patch can be constructed without excavation and feather edged to match the existing grade, or it can involve milling a part or all of the existing asphalt pavement mixtures to repair the distress. In all cases, the patch must match the elevation of the unpatched pavement.

Mark the repair area. If a depression or rut is being repaired, the repair will extend to where the area is the same elevation as the surrounding pavement.

If the patching procedure involves pavement removal, mill to a depth necessary to removed the distressed material. (Figure 3.6). After removal of the pavement, thoroughly clean the area with high pressure air, brooms,

Figure 3.6 Pavement Milling Machine

and/or water. After the area is clean and dry, apply a tack coat to the edges and the bottom of the patch area.

After the tack coat has set, rapidly place hot mix asphalt in the removed area or over the area being patched. For surface patches, a fine or sand asphalt mix is preferable, especially if the patch is placed without milling any of the existing pavement. Without milling, the surface must be "feather-edged" to zero thickness at the edge of the patch. Compact the asphalt with equipment appropriate for the size of the patch. When fully compacted, the patch should be level with the surrounding surface. A fog seal applied to the feather edge will minimize raveling.

Asphalt Pavement Distress

Asphalt pavement distresses can generally be classified as one of five types:

- Cracking
- Distortion
- Disintegration
- Skid Hazard
- Surface Treatment Distresses

Distress causes can be related to:

- Wheel loads
- Environment
- Poor drainage
- Material deficiencies
- Construction related deficiencies
- External causes (utilities, etc.)

Sometimes the distress will be caused by a combination of these factors, and, as well, not all distresses can be categorized. It requires understanding of the present conditions to select the best maintenance action for any given distress or combination of distresses. Proper and timely maintenance will halt the progress of a distress and can even cure or correct the distress. Reconstruction and rehabilitation are beyond the scope of this manual. See *Asphalt Overlays for Highways and Street Rehabilitation (MS-17)*, Asphalt Institute, for in depth information on reconstruction and rehabilitation. All of the distresses are presented by first describing the distress then addressing the causes and repair alternatives.

➤➤ Cracking

Cracking takes many forms. To make proper repairs, it is necessary to first determine the cause of cracking. Individual crack filling may be the right treatment in some cases. Where there are many small cracks in a large area, a surface treatment or slurry seal may be the appropriate repair. In other situations, complete removal of the affected area and the installation of drainage may be necessary before effective repairs can be accomplished. Maintenance procedures generally depend on the cause of the distress, the crack width and the amount of cracking in the affected area. It is necessary to prevent the infiltration of water and incompressibles (rocks, sand, etc.) into the crack and the underlying pavement structure.

Reflective Cracks. These are cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath. The pattern may be longitudinal, transverse, diagonal, or block. They occur most frequently in asphalt overlays on pcc (Figure 3.7) and on cement or pozzolanic-treated bases. They may also occur in asphalt overlays on asphalt pavements where cracks in the old pavement have not been properly repaired.

Reflective cracks are caused by vertical or horizontal movements in the pavement beneath the overlay, induced by expansion and contraction with temperature or moisture changes. They can also be caused by traffic or earth movements or by a loss of moisture in subgrades with high clay contents.

Seal or repair cracks based upon size and severity. (See page 24)

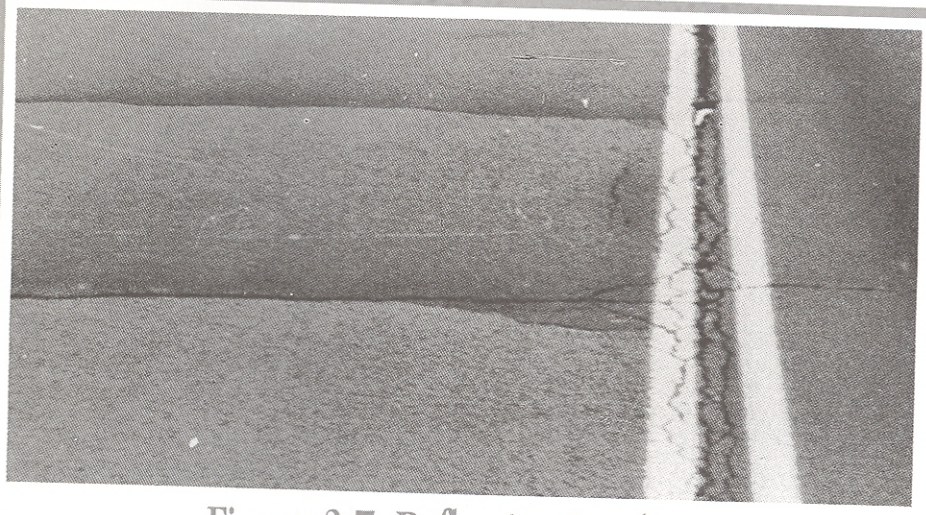


Figure 3.7 Reflective Cracking

Figure 3.8 Edge Cracking

Edge Cracks. These are longitudinal cracks, 30 cm (1 foot) or so from the edge of the pavement with or without transverse cracks branching to the shoulder (Figures 3.8).

Usually, edge cracks are due to lack of lateral (shoulder) support. They may also be caused by settlement or yielding of the material underlying the cracked area. This may be the result of poor drainage, frost heave, or shrinkage from drying out of the surrounding earth. Edge cracking may be aggravated by a concentration of heavy traffic near the edge of the pavement, as well as heavy vegetation close to the pavement edge.

Edge cracking repair will depend on the severity of the distress. Simple cracking can be repaired by sealing or by filling cracks with asphalt emulsion slurry or a sand asphalt mixture. If the shoulder is not supporting the edge of pavement, remove the poor material and replace it with well compacted, good quality material. If water is a contributing factor, install the drainage needed to alleviate the problem.

Block Cracking (Shrinkage Cracking). Block cracks are interconnected cracks forming a series of large blocks, 1 to 3 meters (3 to 10 feet) across, usually with sharp corners or angles (Figure 3.9).

Often it is difficult to determine whether block cracks are caused by volume change in the asphalt mix or in the base or subgrade. Frequently, they are caused by volume change of fine aggregate asphalt mixes that have a high content of low penetration asphalt and adsorptive aggregates. Lack of traffic

Figure 3.9 Block Cracking

hastens shrinkage cracking in these pavements. Another cause is the daily temperature cycles and the hardened (aged) asphalt. Block cracking is not load related.

Generally, block cracks are too numerous to economically seal with a crack sealant. Typically, a surface seal can be applied. Fill large cracks with asphalt emulsion slurry followed by a surface treatment or a slurry seal. An overlay may also be required.

Alligator Cracking (Fatigue Cracking). Alligator cracks are interconnected cracks forming a series of small blocks resembling an alligator's skin (Figure 3.10).

Alligator cracking is caused by excessive deflection of the pavement surface. This can be caused by the subgrade or granular base course weakened by moisture; insufficient pavement thickness; an asphalt surface too thin; or overloading of the pavement. The affected areas are generally not large but often will cover entire sections of a pavement. When this happens, it probably is due to repeated heavy loads that exceed the load-carrying capacity of the pavement. If the asphalt surface is thin, alligator cracking can quickly progress into potholing.

A full-strength patch is the best repair. If the distress level is very light, temporary maintenance such as a slurry seal or other surface treatment or skin

Figure 3.10 Alligator Cracking

patching can help extend the time before a permanent repair is needed. Crack sealing is not the most cost effective way to repair alligator cracking.

Slippage Cracks. These are crescent shaped cracks resulting from horizontal forces induced by traffic. The ends of the curved crack point in the direction of the thrust of wheels on the pavement surface (Figure 3.11). This does not mean they invariably point in the direction of traffic flow. If brakes are applied on a vehicle going downhill the thrust of the wheels is reversed due to braking action. Slippage occurring in this circumstance will result in cracks pointing uphill.

Slippage cracks result from the lack of bond between the surface layer and the course beneath. The lack of bond may be due to dust, oil, rubber, dirt, water, or other non-adhesive material between the two courses. Usually, such a lack of bond exists when no tack coat has been used or when no prime coat was used with a thin asphalt lift placed on the aggregate base. Slippage cracks may result from mixtures having a high sand content, as well as due to improper compaction.

Remove the affected asphalt layer and replace with a surface patch.

Linear Cracking. This category includes general cracking such as paving joint cracks (Figure 3.12), construction joints, shoulder joint cracks,

Figure 3.11 Slippage Cracking

Figure 3.12 Paving Joint Cracking

widening cracks, and other longitudinal, transverse and diagonal cracks.

Transverse and diagonal cracks can result from low temperature contraction of the pavement (low temperature cracking), or from shrinkage of cement bound base or subgrade soils. Longitudinal cracks in the wheel path may be fatigue related and eventually progress into alligator cracking. A random occurring longitudinal crack need not be fatigue related, but can be indicative of a sideways yielding subgrade or fill area. The causes of joint cracks (longitudinal or transverse) can be related to thermal stresses or insufficient compaction. They can also be caused by a weak bond in the joint.

Seal or repair cracks based upon size and severity.

➤➤ *Distortion*

Pavement distortion is the result of asphalt layer instability, or granular base or subgrade weakness. It may be accompanied by cracking. Distortion takes a number of different forms: rutting, shoving, corrugations, depressions, and upheaval. As with any other defect, the cause must be determined before the correct repair can be determined. Repair techniques include full depth patching; complete removal of the affected area and replacing with new material; skin-patching; leveling the surface by filling with new material; or micro-surfacing.

Rutting. Ruts are channelized depressions in the wheel tracks of the pavement surface (Figure 3.13). In severe cases, pavement uplift may occur along the sides of the rut.

Rutting results from consolidation or lateral movement of the subgrade, aggregate base, and/or asphalt layers under traffic load. Rutting may occur in the subgrade or aggregate base due to insufficient design thickness, lack of compaction, or weakness caused by moisture infiltration. Rutting may also occur within a weak asphalt mixture, characterized by a downward and lateral movement of the mixture under heavy wheel loads.

The repair of rutting will depend heavily on the cause. If the cause is in the surface, a permanent repair is made using a full depth patch or a hot mix asphalt overlay with a leveling and surface course. Skin patching, micro-surfacing, or a "strip" chip seal in the rut may also be used effectively, but typically as a temporary measure. If the cause is in the base or subgrade, complete reconstruction of the pavement may be necessary, including the addition of drainage if water is a contributing factor.

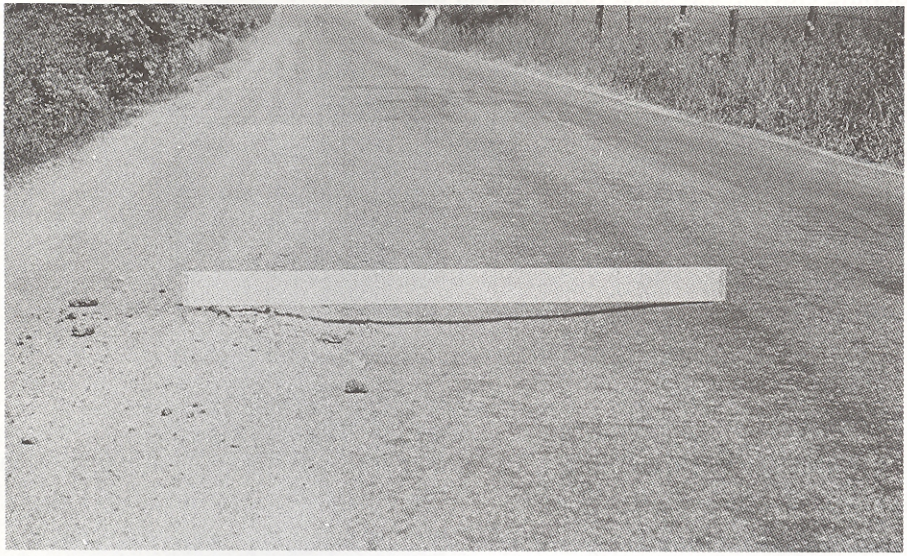


Figure 3.13 Rutting

Corrugations and Shoving. Corrugations and shoving (sometimes called "washboarding") are a form of plastic movement typified by ripples across the asphalt pavement surface (Figure 3.14). They normally occur at points of severe horizontal stress, where traffic starts and stops, on hills

Figure 3.14 Corrugations

where vehicles brake on the downgrade, on sharp horizontal curves, or at intersections.

Corrugations and shoving usually occur in asphalt layers that lack mix stability. Stability deficiencies may result from mixtures too rich in asphalt, too high in fine aggregate content, round and smooth textured aggregates, or too soft an asphalt cement. It may also be due to excessive moisture in the granular base, contamination due to oil spillage, or lack of aeration when placing mixes using emulsified or cutback asphalts.

The best repair is a full depth patch. If the pavement has an aggregate base with a thin surface treatment, scarify the surface, mix with the base material, and recompact before resurfacing. If pavement has more than 50 mm (2 in.) of asphalt surfacing and base, shallow corrugations can be removed with a pavement milling machine, followed with a hot mix asphalt overlay to provide the necessary structural strength.

Settlement or Grade Depressions. Depressions are low areas of limited size that may be accompanied by cracking. These "bird baths" collect water (Figure 3.15) and are not only a source of pavement deterioration but are a hazard to motorists. These depressions can be noticed in dry weather where the pavement is stained.

Depressions may be caused by traffic overloading, or by consolidation, settlement or failure of the lower pavement layers.

Minor settlements and depressions can be repaired by surface treatments or micro-surfacing. Larger areas are repaired by a skin patch or full depth patching.

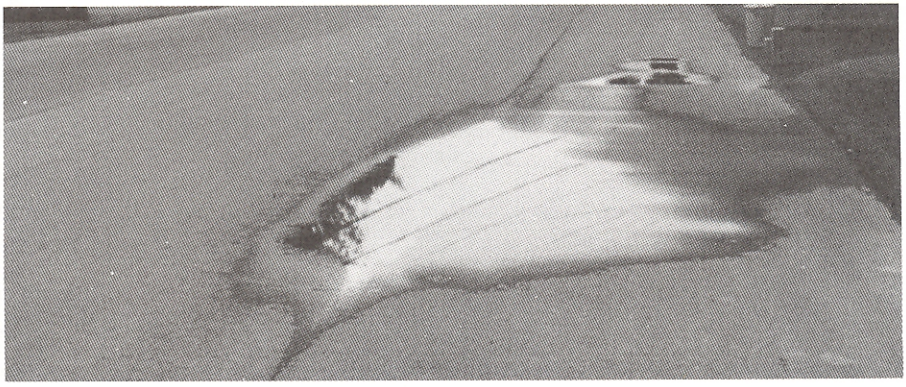


Figure 3.15 Depression

effect of moisture on expansive soils.

Repair using a full depth patch. Permanent repair should also correct or stabilize the moisture condition in the pavement structure.

Utility Cut and/or Patch Failure. This is a failure of a utility installation (Figure 3.17), or of a repaired area in an existing pavement. Deteriorated patches may exhibit disintegration, distortion, cracking, spalling, or delamination between the patch and the original surface. Depressions are usually are caused by lack of adequate compaction of the backfill, base or asphalt patch material. Patch failures may also result from poor installation techniques, inferior materials, or failure of the surrounding or underlying pavement.

Permanent repair requires a full depth patch.

➤➤ Disintegration

Disintegration is the breaking up of a pavement into small, loose fragments. This includes the dislodging of aggregate particles. If not stopped in its early stages, it can progress until the pavement requires complete rebuilding. Two types of disintegration are ravelling/weathering and potholes.

Raveling/Weathering. This is the progressive separation of aggregate particles from the pavement surface downward or from the edges inward. Usually, the fine aggregate comes off first and leaves little "pock marks" on the pavement surface. As the erosion continues, larger and larger particles are broken free and the pavement soon has the rough and jagged appearance typical of surface erosion. Raveling is usually found in the wheel path area (Figure 3.18) while weathering is usually found in low or non-traffic areas and covers the entire surface.

Raveling is caused by lack of HMA compaction, construction of a thin lift during cold weather, dirty or disintegrating aggregate, too little asphalt in the mix, or overheating of the asphalt mix. Raveling almost always requires the presence of both traffic and water to occur.

Raveling surfaces, dry and weathered surfaces, and porous surfaces are conditions that usually require a surface treatment such as a chip seal or slurry seal. These treatments may be considered corrective or preventive maintenance. In the former case they are used to correct an existing condition. In the latter case they are used to prevent an anticipated condition from becoming a reality.

Figure 3.18 Raveling

Potholes. Potholes are bowl-shaped holes resulting from localized disintegration (Figures 3.19). Potholes are often the severe, uncorrected result of another distress, such as alligator cracking, upheaval, raveling, or failed patches or utility cut repairs. It is common to have a pothole extend through or into the aggregate base.

Most potholes occur in pavements having a thin asphalt concrete surface on an untreated aggregate base. Thin surfaces showing severe alligator cracking begin to lose pieces of asphalt out of the cracked area, creating potholes. Thicker asphalt pavements [greater than 100 mm (4 in.)] generally do not develop potholes in this way because the pieces do not become dislodged.

A permanent repair is made using a full depth patch. Temporary repairs usually involve cleaning out the pothole and filling it with a cold-mix asphalt patching material.

➤➤ Skid Hazards

Few dry pavements are slippery. However, there are a number of things that can make a pavement slippery when wet. One of the most frequent causes of slippery asphalt pavements is a thin film of water on a smooth surface. Another is a thick film of water that causes a high speed vehicle to hydroplane. A smooth pavement condition is usually the result of a

Figure 3.19 Pothole

film of asphalt on the surface, or polished aggregate in the surface course. Slipperiness may also develop from surface contamination, such as from oil spillage or certain types of clay. The object of skid hazard improvement is to restore the pavement surface to a condition where water can flow around most of the surface aggregate particles, leaving contact between tire and aggregate.

Corrective treatments to improve surface drainage and skid resistance include cleaning the surface of contamination, surface treatments, or milling and resurfacing.

Bleeding or Flushing. Bleeding, or flushing, is the upward movement of asphalt in an asphalt pavement. This results in the formation of a film of asphalt on the surface (Figure 3.20). Bleeding is identified by a pavement surface with a slick, glassy appearance that may be sticky to the touch, and usually occurs in hot weather.

The most common cause of bleeding is excess asphalt in one or more of the pavement courses. This can result from an improperly constructed seal coat, too much asphalt in a mix, and/or too heavy of a prime or tack coat or excessive sealant in cracks or joints below an overlay. Also, traffic may cause over compaction of asphalt layers, forcing the binder to the surface.

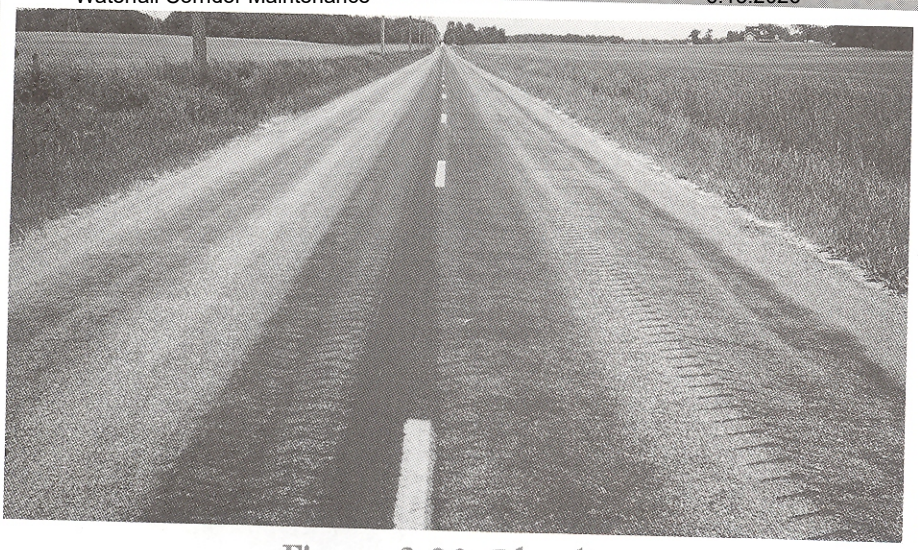


Figure 3.20 Bleeding

In many cases, bleeding can be corrected by repeated applications of hot sand, hot slag screenings, or hot rock screenings to blot up the excess asphalt. In this procedure, apply 9.5 mm (3/8 in.) maximum size slag screenings, sand, or rock screenings to the affected area. The aggregate should be heated to at least 150°C (300°F) and spread at the rate of 5.4 to 8 kg/m^2 (10 to 15 lb/yd^2). Immediately after spreading the aggregate, roll with a pneumatic-tired roller. When the aggregate has cooled, broom off the loose particles. Repeat the process, if necessary.

If bleeding is light, an aggregate seal coat, using absorptive aggregate, is the only treatment needed. A hot mix asphalt leveling course with a low asphalt content can also be effective in absorbing the excess asphalt. With this treatment, however, a new surface course is needed over the leveling course to prevent raveling. A pavement milling machine can also be used to remove the excess asphalt. In rare instances of heavily over-asphalted surfaces, the surfaces should be completely removed.

Polished Aggregate. These are aggregate particles in the surface of a pavement that have been polished smooth. This includes both naturally smooth uncrushed gravels and crushed rock that wears down quickly under the action of traffic (Figure 3.21).

Some aggregates, particularly limestone, become polished rather

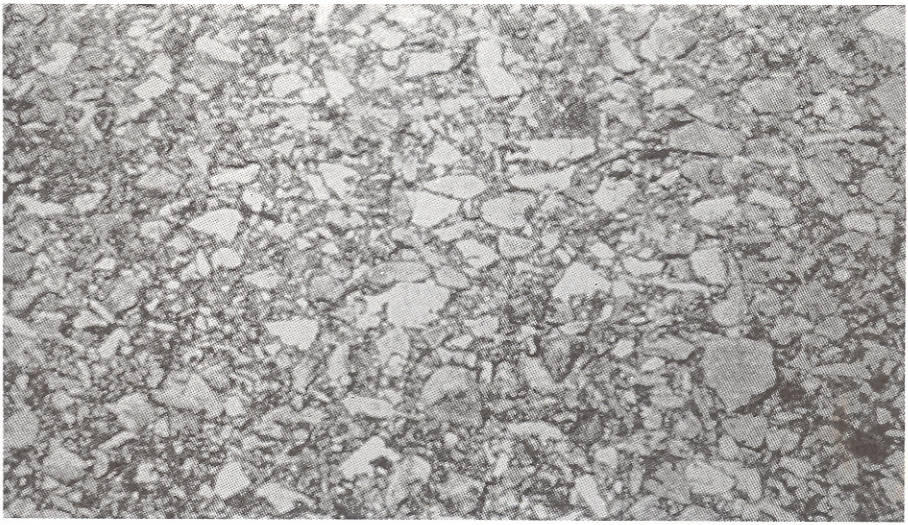


Figure 3.21 Polished Aggregate

quickly under traffic. Some types of gravel are naturally polished and if they are used in a pavement surface without crushing they will be a skid hazard. These polished aggregates are quite slippery when wet.

One of the most effective ways to repair a pavement with polished aggregates is to cover the surface with a skid resistant treatment. This may be a hot mix asphalt overlay, a sand seal, or an aggregate seal coat. The aggregate must be hard and angular, using proven non-polishing material.

➤➤ *Surface Treatments Distresses*

Because of the construction procedures used, surface treatments may develop some defects that don't occur in other types of asphalt pavement surfaces. These include the loss of cover aggregate and streaking.

Some of the other asphalt pavement defects described earlier in this chapter, such as corrugations, depressions, upheaval, potholes, and raveling, occur most frequently in pavements constructed with surface treatments. This happens because the thin asphalt surfacing usually is placed over an under designed pavement structure

Loss Of Cover Aggregate. This distress is identified by the whipping-off of aggregate by traffic from a surface-treated pavement (Figure 3.22).

Figure 3.22 Loss of Cover Aggregate

Several things can cause the loss of cover aggregate. If the aggregate is not spread immediately after the asphalt is applied to the pavement surface (usually within one minute), the aggregate may not hold. Aggregate that is too dusty or too dry when spread may not be able to bond with the asphalt. The aggregate must be rolled immediately after placement to firmly seat it and hold under traffic. If a steel-wheeled roller alone is used for compaction, aggregate may be lost from low spots that are bridged over by the roller. Other reasons are include weather too cool when treatment was applied; fast traffic permitted on the new surface treatment too soon; and a surface that absorbs part of the asphalt, leaving too little to hold the aggregate.

Hot coarse sand, spread over the affected areas, may be used to replace the lost aggregate. On a hot day, spread coarse sand, heated to at least 150°C (300°F), over the area that has lost cover aggregate. Follow *immediately* (before the aggregate has had a chance to even cool a few degrees) with a pneumatic tired roller to seat the aggregate into the asphalt.

If aggregate is only partially whipped-off, an absorptive aggregate seal coat may be a practical treatment.

Longitudinal / Transverse Streaking. Longitudinal streaking is alternating lean and heavy lines of asphalt and/or aggregate running parallel to the centerline of the road (Figure 3.23). Transverse streaking is the same

Figure 3.23 Longitudinal Streaking

phenomena except that the direction is running transverse across the roadway.

Several things can cause longitudinal streaking are:

- The spray bar on the asphalt distributor is not set at the correct height for the spray fans to overlap properly.
- The spray bar is rising as the load in the distributor lightens.
- The nozzles on the spray bar are not set at the correct or same angle, are the wrong size or not all the same size, some are plugged with cold asphalt, or have imperfections.
- Incorrect asphalt pump speed
- Asphalt too cool
- Incorrect pump pressure
- A single centerline streak may be caused by too little or too much asphalt at the matching joint between two applications

Transverse streaking is caused by spurts in the asphalt spray from the distributor spray bar. These spurts may be produced by pulsation of the asphalt pump due to worn or loose parts, by improper pump speed, or by a miss in the motor.

The satisfactory repair for longitudinal and transverse streaking is to plane off the streaked surface and apply a new surface treatment, or apply a second treatment over the streaked surface.

Note: It is much easier to prevent streaking than to correct it. Careful adherence to the distributor manufacturer's recommendations will guard against streaking. See *Asphalt Surface Treatments-Construction Techniques (ES-12)*, and *A Basic Asphalt Emulsion Manual (MS-19)*, Asphalt Institute, for recommendations and checks to ensure proper operation of the asphalt distributor.

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CHAPTER 4

ASPHALT IN MAINTENANCE OF PCC PAVEMENTS

Asphalt has an important role in the maintenance of portland cement concrete pavements. It seals joints and cracks, fills cavities and raises sunken slabs. It renews disintegrating pavements and covers slick surfaces. More specifically, asphalt and asphalt mixtures are used in the maintenance of portland cement concrete pavements to:

- Restore design grade and surface smoothness
- Repair and retard spalling, scaling, and other deterioration
- Repair badly broken areas
- Improve skid resistance
- Keep foreign material out of joints and cracks
- Keep water out of the base
- Prevent pumping and stabilize the subgrade
- Stop slab rocking
- Prevent damage from frost action
- Stop disintegration from use of de-icing chemicals

Asphalt, if used correctly, can do an excellent job in repairing many defects in pcc pavements. The techniques discussed in this chapter are not the only correct ones. They are methods that have been proven satisfactory by use.

Joint and Crack Sealing

Joint and crack sealing are done for several reasons: to prevent surface water seepage, to protect joint fillers, and to keep out foreign matter. At one time, asphalt cement, alone or with filler added, was the commonly used sealing material. Currently, rubber-asphalt compounds are generally used. These sealants have less tendency to become brittle in cold weather, or to soften and track under traffic in hot weather. Sealants meeting the requirements found in ASTM Specification D1190, D3405, or D5078, or AASHTO Specification M173 are generally used for pcc joint and crack sealing.

Joints are formed either the full depth of the slab or sawn or grooved to a depth of one-third to one-quarter of its thickness. Full-depth joints are junctions between slabs to permit expansion,

or to meet construction requirements. Grooved joints are formed or cut to force cracking along the weakened plane. Depending upon their function, they are called expansion joints, contraction joints, or construction joints. They normally run in a transverse or longitudinal direction. In the case of odd shaped slabs they may be skewed.

Another type of joint is the one between the pcc slab and the shoulder. It is a longitudinal construction joint called a shoulder joint. Also, there are other types of joints that have special purposes. All are maintained in the same way.

The methods used for sealing joints and cracks are essentially the same. Both consist of cleaning out the upper portion of the joint or crack reservoir and filling them with a sealing material. To be effective, the sealing material must stick to the sides of the opening. For this reason any material that will prevent a good bond must be removed. If sand, gravel, dust, or other foreign matter has accumulated in the joint or crack they must be removed to prevent spalling when the joint or crack closes under expansion of the slab in hot weather. Old sealing materials become hard and brittle and should also be removed.

If the job is small, the cleaning operations may be performed by hand. Stiff fiber or steel bristle brooms and bars with chisel ends shaped to fit the joint opening are tools that can be used. For larger jobs, the work can be done more rapidly with joint plows, power rotary cutters or pavement saws, air compressors, or similar equipment. Special treatment may be necessary where the joint or crack is very narrow or has badly spalled edges. When such conditions are encountered, areas to be sealed may be grooved out with a power driven pavement saw or rotary cutter.

➤➤ *Joint Sealing Procedures*

Joints needing resealing should be cleaned out to an approximate depth of 25 mm (1 in.) with a joint plow, saw or by waterblasting to "reface" the joint. Remove any residual material after refacing by sandblasting or high pressure water cleaning. Before the new sealant is applied, all surfaces in and around the joints should be clean and dry, with no bits of filler or old seal clinging to the sides. Filler or backer rod material with a melting temperature greater than the pouring temperature of the sealant should be inserted into the groove to provide a non-adhesive lower face for the seal.

Apply the proper sealant using pressure injection wand. It is best to follow the manufacturer's directions for heating requirements for hot-applied sealants. If a cold applied sealant is used follow the manufacturer's application procedure.

The sealant should be applied from the bottom to the top of the joint. Care should be taken not to overfill the joint. The sealant should be 3 to 6 mm (1/8 to 1/4 in.) below the pavement surface to avoid extrusion.

If the pavement is to be opened to traffic immediately after sealing, the material must be protected against pick-up by tires. This can be done by dusting the joints and cracks with fine sand, mineral dust or similar materials.

➤➤ *Crack Sealing Procedures*

Different procedures are required based on crack width and amount of spalling for different classifications of cracks. These procedures are general guidelines that may vary according to local policy:

- ***Small cracks,*** less than 3 mm (1/8 in.). If there is no spalling, do not widen or seal. If they have minor spalling, blow out and seal.
- ***Medium cracks,*** 3 to 12 mm (1/8 to 1/2 in.). If they are not spalling and the edges are rough, blow out or rout before sealing. If only minor spalling is present, rout and seal.
- ***Large Cracks,*** greater than 12 mm (1/2 in.). If no spalling is present, rout and seal, using a backer rod to conserve sealant, as necessary. If there is major spalling, rebuild the crack as if it were a joint, or patch using an asphalt mixture.

If needed, rout out the crack with the appropriate machine then clean the cracks using sandblasting or water blasting. It is best to follow the sealant manufacturer's specifications for width to depth ratio. If the crack is deep, install a backer rod and finish by sealing the cracks using the same procedure as sealing joints.

Patching

Asphalt patches are effective for many pcc pavement distresses. The typical patches are partial depth patches or full depth patches, and their use will vary with the depth of the distress. Skin patches (see Chapter 3) can also be used effectively as a temporary repair.

➤➤ *Full Depth Patching*

Full depth patches are necessary for these pcc pavement distresses:

- Shattered Slabs
- Corner Breaks
- Cracking
- Punch-out
- Faulting/Settlement
- Blow-up
- Patching/Utility Cuts

Except for patching/utility cuts, these are structural distresses. This means that the pavement is not able to carry the loads it was designed to carry. Therefore, they require full depth replacement of the affected areas.

First determine and mark the repair area. After marking, isolate the removal area from the rest of the pavement by cutting the full depth of the concrete, if possible. The patch area should be rectangular with vertical sides to facilitate the proper placement and compaction of the backfill materials. If the cut is for a utility repair or installation, you can make the cut a little beyond the limits of the trench. If a full depth cut is used, remove the area by either breaking out with a jackhammer or by the lift-out method. The lift out method involves drilling holes in the removal area and inserting lift pins. A front-end loader or other appropriate equipment is used to lift out the area of pavement to be replaced.

If a full depth cut isn't possible, then make partial depth cuts and use the breakout method of removal. The breakout method is done with jackhammers, drop hammers, or hydraulic rams. Remember that the impact of these tools can damage the sound concrete. The removal is done as near vertical as possible. Once broken up, the concrete can be removed using a backhoe or a front-end loader.

After removal of the failed pavement, any unstable base material needs to be removed and replaced. Replace base material with a select nonplastic granular material. Thoroughly compact the material at optimum moisture content. The lift thickness will be determined by the type of compaction equipment available. Correct poor drainage if necessary.

Apply a tack coat to the pcc faces of the patch area, and a prime coat to the base (see Chapter 2).

Place and compact the dense-graded hot mix asphalt, in lifts if needed. The compaction equipment should be the largest that will fit into the repair area. The lift thickness will be determined by the compaction equipment. The final surface should be finished flush with the surrounding pavement. Remember to replace and seal the joint and any saw kerfs.

➤➤ *Partial Depth Patching*

This repair method is used to repair pop-outs, scaling, and spalling. These are not structural distresses and normally do not extend the full depth of the pavement. Therefore, only the affected pcc pavement needs to be removed. If the affected area extends beyond half of the slab thickness, repair it using a full depth patch.

Determine and mark the repair area then saw cut a rectangular pattern around the affected area. Boundary cuts should be a few inches outside the distressed area. Overlap the cuts at the corners to provide square vertical edges.

Break out the material within the cut area down to sound concrete. After removing the defective pcc, clean the area with sand blasting or high pressure water cleaning, and blow out with compressed air. Once clean apply a tack coat to the sides and bottom of the repair area (see Chapter 2).

After preparation, place and compact asphalt patching mixture and compact. The final surface should be flush with the surrounding pavement.

Undersealing

Cavities may occur beneath a portland cement concrete pavement as a result of pumping of the slabs or settlement of the subgrade. When this happens they should be filled to restore the pavement's support and prevent further erosion. Undersealing asphalt is used for this purpose. It fills the cavities, raises sunken slabs, and forms a waterproof layer that prevents fine material from pumping out again. Asphalt for undersealing should meet ASTM D 3141 (AASHTO M 238).

Asphalt Overlays

For many types of defects in pcc pavement an asphalt overlay is the most effective and most economical treatment. Rough and/or faulted pavements often can be restored to smoothness with asphalt overlays. Disintegrating pavements can be salvaged and strengthened with them. Slippery pavements can be made skid resistant with the proper asphalt overlays.

Overlays are generally considered construction rather than

maintenance. However, overlays can be used for short periods of time as a maintenance operation. See ***Asphalt Overlays for Highway and Street Rehabilitation (MS-17)***, Asphalt Institute, for discussions of overlays, including thickness requirements, and rehabilitation treatments for preventing reflective cracking in the asphalt overlay, such as cracking and seating, rubblizing, and sawcut and sealing.

Rigid Pavement Distress

Rigid pavement distresses can be classified as:

- Cracking
- Deformation
- Disintegration

This discussion provides descriptions of these distresses, their most common cause, and suggested methods of repair, assuming that it is the only distress type present. Other problems such as those resulting from improper construction and maintenance are normally corrected with materials other than asphalt and not discussed in this manual.

➤➤ *Cracking*

Relatively large volume changes are produced in portland cement concrete by temperature variations. This phenomena results in cracking; it is a natural property of the material. To make the concrete crack in neat, straight

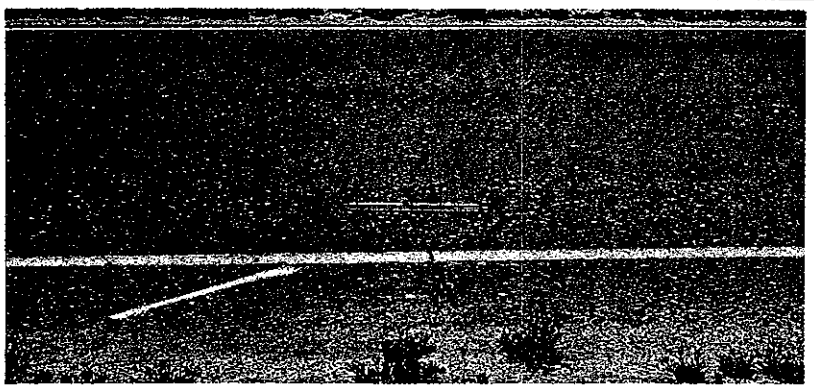

Figure 4.1 Transverse Cracking

lines pcc pavements have joints at frequent intervals. Additional cracks result from stresses caused by contraction or warping of the pavement. Poor jointing arrangements and/or inadequate curing help generate excessive contraction movement prior to attainment of the design strength of new concrete.

All joints and cracks must be kept sealed with adhesive material to prevent damage to the pavement from water and foreign matter. If the joints or cracks are not sealed and kept sealed distresses result and eventually lead to complete deterioration of the pavement.

Linear Cracking. These are longitudinal, transverse and diagonal cracks typically through more than one quadrant of a slab that divide the slab in two or three pieces. Longitudinal cracks run approximately parallel with the longitudinal joints. Transverse cracks (Figure 4.1) run approximately parallel with the transverse joints (or approximately at right angles to the centerline of the pavement). Diagonal cracks form a triangle with a longitudinal edge or joint and a transverse joint or crack.

Linear cracking can result from a number of causes acting singly or in combination. The principal causes include:

- Traffic overloads, insufficient pcc strength or slab thickness
- Warping and curling stresses (temperature related)
- Loss of support, usually as a result of pumping
- Improper slab width to length ratio (joints too far apart)
- Joints not of sufficient depth, improperly sealed, "frozen" joints, or lack of joints. The biggest problem is the infiltration of water and incompressibles into and through the joint which creates insufficient room for expansion
- The lack of proper load transfer at the joints, misaligned or frozen dowels, or too wide joints

If cracking is caught early or there are no structural problems, clean and seal the crack. If there are structural problems use a full depth patch. If there are voids under the slab, underseal with asphalt.

Corner Break. These are diagonal cracks forming a triangle with a longitudinal edge or joint and a transverse joint or crack (Figure 4.2). They extend the full depth of the slab and are confined to one quadrant of the slab.

Corner breaks are caused by overloading combined with a loss of subgrade support or a thin slab. The lack of support may be created by

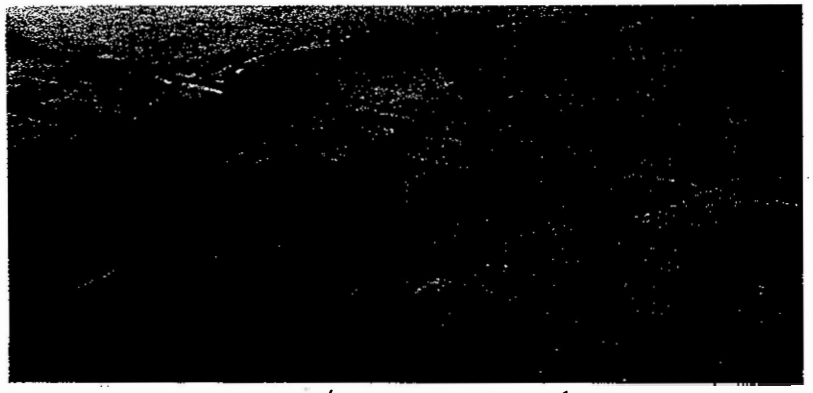

Figure 4.2 Corner Breaks

curling or warping stresses, pumping, or loss of load transfer at the transverse and longitudinal joints.

The best repair is a full depth patch. Cleaning and sealing the cracks can provide temporary relief from water infiltration into the pavement.

Shattered Slab. A shattered slab is the break up of the concrete slab into four or more pieces (Figure 4.3).

This distress is caused by poor base support, fatigue of the concrete layer, or break up of the concrete slab due to further progress of several of the other types of cracking. It is aggravated by overloading. Progressive deterioration will include distortion and spalling of the shattered area. This condition is a complete failure of the slab.

Full depth patching is the best means of repair. However, if the problem is widespread, pavement reconstruction with an asphalt overlay may be the proper solution. See *Asphalt Overlays for Highway and Street Rehabilitation (MS-17)*, Asphalt Institute.

➤➤ Deformation (Distortion)

Deformation is any change of the pavement surface from its original shape. Faulting is one of the most predominant types of pcc pavement deformation. Pumping cannot be classified as distortion but it results in faulting or sunken slabs. Therefore, it is included in this section. Major causes of deformation are expansive soils, frost susceptible soils, and foundation settlement.

Figure 4.3 Shattered Slab

If not too extensive, some forms of deformation (such as from settlement) can be remedied by raising the slab to bring it back to the original grade. One method of doing this is by pumping a high softening point undersealing asphalt under the slab. Sometimes the pavement surface is so badly distorted that an asphalt concrete overlay is the most economical repair.

Punch-Out. A punch-out is a localized area of a pcc pavement broken into many small pieces (Figure 4.4), often accompanied by a sunken, "punch out" appearance.

Punch-outs are caused by repeated heavy loads combined with a thin slab section or a construction deficiency such as honey-combing.

Repair is accomplished by placing a full depth patch.

Faulting (Settlement). Faulting is a difference in elevation across a joint or crack (Figure 4.5).

Faults usually develop from inadequate load transfer between slabs combined with consolidation or shrinkage in volume of courses underlying the slabs. They may be also be caused by the pumping out of base or subgrade material.

If possible, bring faulted slabs back to the original grade by undersealing. In some cases, it may be necessary to place wedge-type patches for leveling, followed by an asphalt overlay.

Figure 4.4 Punch-out

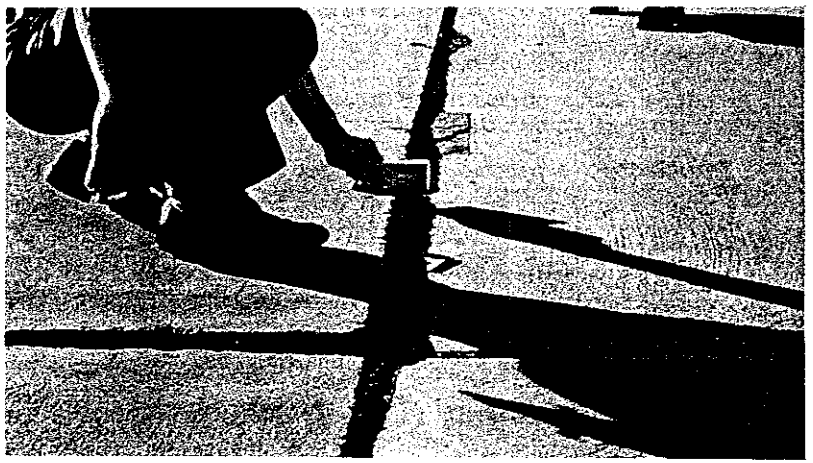

Figure 4.5 Faulting/Settlement

Blow-ups. A blow-up is the localized buckling (upward movement) of a pcc pavement usually occurring at a transverse crack or joint (Figure 4.6). Blow-ups can also occur at drainage structures or utility cuts.

Most blow-ups are caused by excessive expansion of the slabs during hot weather. The pressure builds up until the slabs cannot resist it any longer and they either buckle or shatter, crumbling along a transverse joint or crack.

Figure 4.6 Blow-up

A contributor to blow-ups is the infiltration of incompressible materials into joints that prevent expansion of the concrete slabs.

Repair using a full depth patch.

Lane-shoulder drop-off. A difference in elevation between the traffic travel lane and the shoulder (Figure 4.7).

Causes of lane-shoulder drop-off can be differential settlement, shoulder erosion, insufficient design thickness of shoulder if used by traffic,

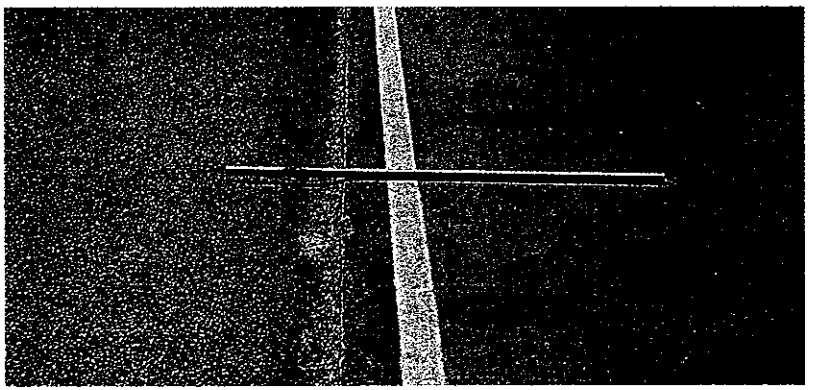

Figure 4.7 Lane-Shoulder Drop-Off

poor compaction or drainage.

If the height difference is relatively small and the shoulder is asphalt, a hot mix asphalt wedge can be placed to bridge the height difference. If the height difference is great the shoulder should be reconstructed and/or overlaid. If poor drainage is a factor ensure proper drainage is installed. If the shoulder is unpaved, remove and replace deficient material with a better quality, well compacted material.

Pumping. Pavement pumping is the forceful ejection of water by deflection of a pavement slab (Figure 4.8). This usually carries subgrade particles in suspension from beneath the slab and up through cracks, joints, and along pavement edges. Often, pumping can be identified by stains or excess base material on the pavement surface along the joint or crack.

It is caused by an unfavorable combination of free water and subgrade material susceptible to pumping, and continuous use by traffic. The slab is forced downward under wheel loads, this compresses any free water between the slab and subgrade, which forces the water and soil out through cracks and joints. Repetition of this pumping action displaces subgrade soil and results in voids and cavities beneath the slab that leave the slab unsupported and subject to cracking. Good surface drainage, sub-drains, and sealed joints reduce the probability of free water accumulating and contributing to pumping action.

Figure 4.8 Pumping

Sealing the joints and cracks to avoid further water intrusion, undersealing to fill the voids under the slabs, and improvement of the surface and subsurface drainage will reduce and/or eliminate further pumping.

➤➤ *Disintegration*

Disintegration is the breaking up of a pavement into small, loose fragments. This includes the dislodging of aggregate particles. If not stopped in its early stages, it can progress until the pavement requires complete rebuilding. Common types of disintegration in pcc pavements that can be repaired with asphalt are spalling, and scaling or crazing/map cracking. Treatment ranges from skin patches to complete overlays.

Typically nothing is done to pop-outs they are small and not deep. A seal coat can waterproof the pcc surface and stop further progress of this type of distress. When left unmaintained pop-outs can progress to a stage where an asphalt overlay will be needed.

Durability cracking ("D" Cracking). "D" cracking is the progressive formation, seen on the surface, of a series of fine cracks at rather close intervals, paralleling edges and joints, curving around corners where joints intersect or cracks intersect edges. "D" cracking usually starts at the bottom of the slab and only becomes visible when it reaches the surface (Figure 4.9).

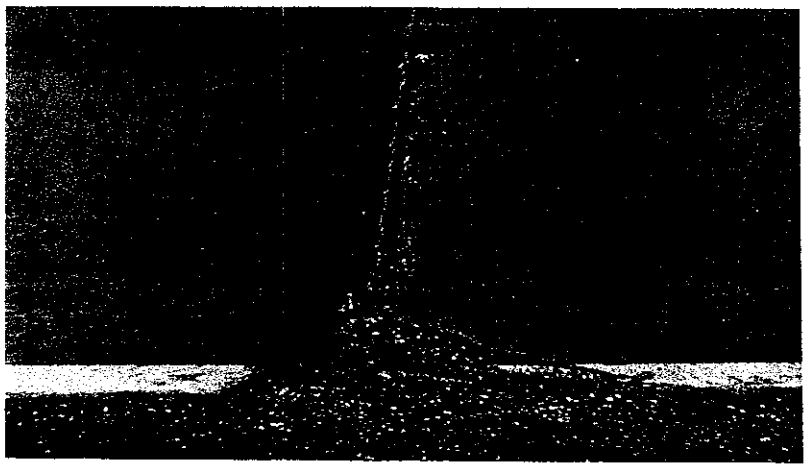

Figure 4.9 "D" Cracking

"D" cracking is caused by repetitive freezing and thawing cycles in the presence of variable expansive aggregates and those having an undesirable pore structure. Moisture is critical to the development of "D" cracking, so, if excess moisture can be kept out of the concrete, this type of distress can probably be retarded.

A full depth patch is the proper repair. However, if the problem is widespread, pavement reconstruction with an asphalt overlay may be the proper solution. See *Asphalt Overlays for Highway and Street Rehabilitation (MS-17)*, Asphalt Institute.

Scaling/Crazing/Map Cracking. This is the peeling away of the surface of portland cement concrete (Figures 4.10). In severe cases it can progress the deeper into the pavement..

The major causes of scaling are the chemical actions of deicing materials, overfinishing, improper mixing, unsuitable aggregates, and improper curing.

If affected areas are about 10 mm (3/8 in.) or less in depth temporary repair may be made with asphalt emulsion slurry seal. If they are extensive and deep the pavement should be overlaid with asphalt concrete.

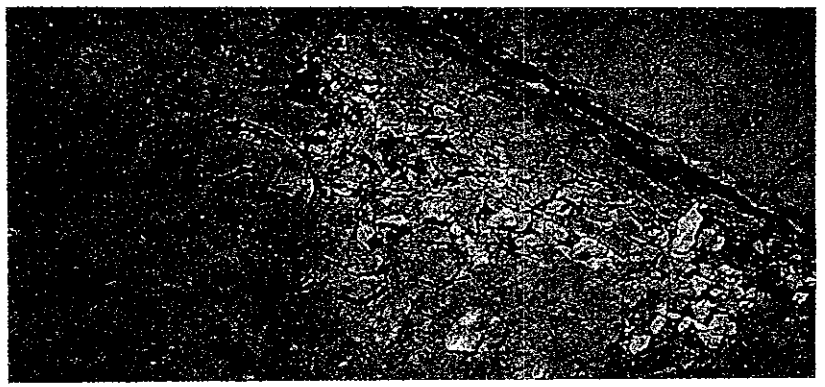

Figure 4.10 Scaling

Joint and Corner Spalling. Joint and corner (Figure 4.11) spalling are the break up or disintegration of the concrete at longitudinal or transverse pavement joints or cracks. A spall normally does not extend vertically through the slab but rather intersects the joint or crack at an angle.

Spalling is usually the result of poor joint or crack sealing, which permits incompressible material to enter the joint or crack. It can also be from improper forming and sawing of joints, and weak mortar. Thermal slab expansion crushes the concrete at joints or cracks filled with incompressibles. Dowels used as load-transfer devices across expansion joints, when not placed parallel to both the center line and the surface of the pavement, may also cause spalling.

A partial depth patch is the best repair.

Figure 4.11 Corner Spalling

Polished aggregate. A number of things can make a pavement slippery when wet. A major cause of slippery portland cement concrete pavements is polished aggregates in the surface (Figure 4.12). The surface will look smooth and/or glassy and feel smooth to the touch.

If poor quality aggregates are used in a mix they wear down and become polished quickly under traffic. Some types of gravel are naturally polished. If these are used in a pavement surface without crushing they become a skid hazard. Polished aggregates have little or no extension above the surface and are extremely slippery when wet.

For effective repair, cover the surface with a skid-resistant asphalt surface treatment or micro-surfacing.

Patches/Utility Cuts. This is any pavement area that has been replaced with asphalt or pcc to repair a pavement defect (Figures 4.13) or to

repair a trench or hole cut into the pavement for access to underlying utility lines. Due to lack of compaction, trench settlement or incorrect patching procedures, the patch and or utility cuts can deteriorate.

To repair, remove the existing patch, re-compact the base and place a full depth patch. A temporary repair may be done by placing a skin patch.

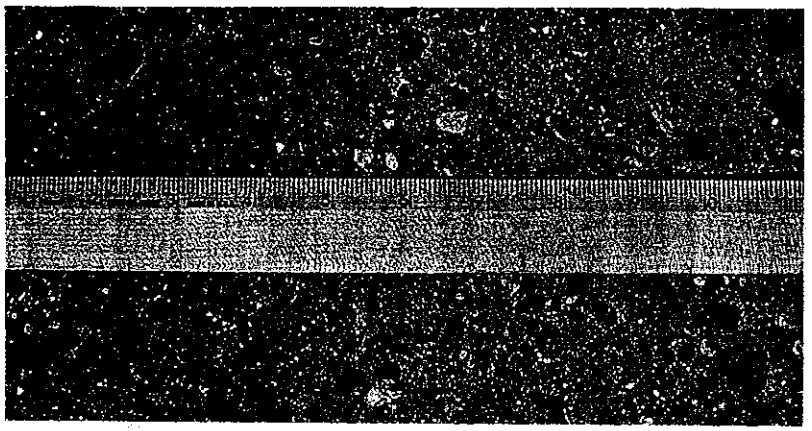

Figure 4.12 Polished Aggregate

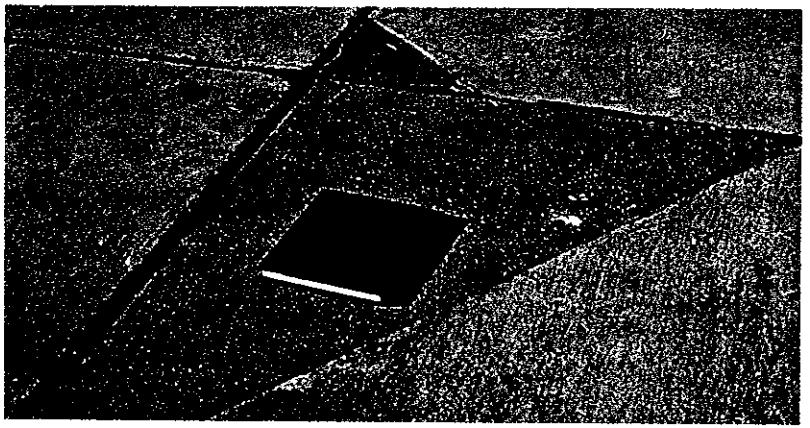

Figure 4.13 Patch

Plant Mixed Asphalt Stockpile Maintenance Mixtures

➤➤ General Requirements

Equipment. The equipment shall include an asphalt mixing plant designed, coordinated, and operated to produce a uniform mixture within the job-mix tolerances.

Samples. Samples for all materials proposed for use under these specifications shall be tested and analyzed. The material shall not be used until it is approved by the engineer. The sampling of asphalt materials shall be in accordance with the latest revision of AASHTO T40 (ASTM D 140). The sampling of mineral aggregates shall be in accordance with the latest revision of AASHTO T2 (ASTM D 75).

Methods of Testing. Asphalt materials will be tested by the appropriate test methods designated in the Materials section. If an AASHTO test method is not available, the ASTM test method will be used.

Mineral aggregates will be tested (Table 5.1) by one or more of the AASHTO test methods. If an AASHTO test method is not available, the ASTM method will be used.

Table 5.1 Aggregate Material Test Methods

Characteristics	Test Method AASHTO	Test Method ASTM
Abrasion of Coarse Aggregate, Los Angeles Machine	T 96	C 131
Sieve Analysis, Fine and Course Aggregates	T 27	C 136
Unit Weight of Aggregate	T 19	C 29
Sand Equivalent	T 176	C 2419

➤➤ Materials

Asphalt. The asphalt shall be as specified by the engineer from Table 5.2 prior to letting the contract. The grade of asphalt material specified shall meet the requirements of the AASHTO or ASTM Specifications listed in Table 5.2.

Table 5.2 Asphalt Materials

Asphalt Grade	Specification AASHTO	Specification ASTM
MC-250	M 82	D 2027
MC-800	M 82	D 2027
SC-250	--	D 2026
SC-800	--	D 2026
CMS-2	M 208	D 2397
CMS-2h	M 208	D 2397
HFMS-2s	M 140	D 977

Mineral Aggregates. The mineral aggregate shall be crushed stone, crushed or uncrushed gravel, slag, sand, stone or slag screenings, mineral dust or a combination of these materials meeting one of these gradations in Table 5.3.

Table 5.3 Mineral Aggregate Gradations

Sieve Size	Mix Designation and Nominal Maximum Size of Aggregate 9.5 mm (3/8 in.)	12.5 mm (1/2 in.)	19.0 mm (3/4 in.)
25.0 mm (1 in.)	—	—	100
19.0 mm (3/4 in.)	—	100	90-100
12.5 mm (1/2 in.)	100	90-100	—
9.5 mm (3/8 in.)	90-100	—	56-80
4.75 mm (No. 4)	55-85	44-74	35-65
2.36 mm (No. 8)	32-67	28-58	23-49
.300 mm (No. 50)	7-23	5-21	5-19
.075 mm (No. 200)	2-10	2-10	2-8

➤➤ Construction

Preparation of Mixture. Coarse and fine aggregate shall be fed into the plant in the proportions required to provide a total aggregate conforming with the gradation specified in the Mineral Aggregates section. The aggregate shall be free from visible moisture at the time of mixing. The asphalt shall be applied at the rate and at the temperature specified by the engineer to produce a final mixture containing from 4 to 6 percent cut-back asphalt (7 to 10 percent asphalt emulsion) by weight of total mix. The mineral aggregate and the asphalt shall be mixed thoroughly until all aggregate particles are completely coated.

Stockpiling. The finished mixture shall be stockpiled in or on an approved storage space.

Method of Measurement. The quantities to be paid for will be the total number of tonnes (tons) of asphalt maintenance mixture delivered to the stockpile.

Basis of Payment. The quantities measured as described in the Method of Measurement section will be paid for at the contract unit price bid for this item. Payment will be in full compensation for furnishing, mixing, hauling, and stockpiling the mixture and for all labor and use of equipment, tools, and incidentals necessary to complete the work in accordance with these specifications.

➤➤ Important Notice to the Engineer

Selection of Asphalt. This may be used as a guide for selecting the type and grade of asphalt for the stockpile mixture:

- MC-250 For immediate use under hot or moderate weather conditions, or for use within a short time after stockpiling
- MC-800 For use within short time after stockpiling
- SC-250 For long period storage in hot, dry climates
- SC-800 For long period storage
- CMS-2 Mix can be designed for use within a short time after stockpiling

CMS-2h Mix can be designed for use within a short time after stockpiling

HFMS-2s Mix can be designed for use within a short time after stockpiling or for long storage period

Amount of Asphalt. The asphalt requirements for the aggregate gradations specified in the Mineral Aggregate section will normally be in the range of 4 to 6 percent by weight of total mix for cutback asphalt and 7 to 10 percent for asphalt emulsion.

Aggregate. Aggregate with high absorption may be unsuitable for stockpile mixtures. The high solvent content and normal low viscosity of many asphalt materials for stockpile mixtures may result in a high penetration of asphalt into the aggregate and cause a dry mix.

Mixed-In-Place Asphalt Stockpile Maintenance Mixtures

➤➤ General Requirements

Equipment. The contractor shall use the equipment necessary to complete the specified work. If the equipment includes an asphalt pressure distributor it shall meet the following requirements:

- The pressure distributor shall be designed and operated to distribute the asphalt material in a uniform spray without atomization.
- The distributor shall be equipped with a bitumeter having a dial registering meters (feet) of travel per minute. The dial shall be visible to the truck driver so that the constant speed required for application at the specified rate can be maintained.
- The pump shall be equipped with a tachometer having a dial registering liters (gallons) per minute passing through the nozzles. The dial shall be readily visible to the operator.
- Means for indicating accurately the temperature of the asphalt material in the distributor at all times shall be provided. The thermometer well shall not be in contact with, or close to, a heating tube.
- The normal width of application of the spray bar shall not be less than 3.5 meters (12 feet), with provision for the application of lesser width when necessary.
- The distributor shall be equipped with heating attachments and the asphalt material shall be circulated through the spray bar during the entire heating process.

Samples. Samples of all materials proposed for use under these specifications shall be tested and analyzed. The material shall not be used until it is approved by the engineer. The sampling of asphalt materials shall be in accordance with the latest revision of AASHTO T40 (ASTM D 140). The sampling of mineral aggregates shall be in accordance with the latest revision of AASHTO T2 (ASTM D 75).

Methods of Testing. Asphalt materials will be tested by the appropriate test methods designated in the Materials section. If an AASHTO test method is not available, the ASTM test method will be used.

Mineral aggregates will be tested (Table 5.4) by one or more of the AASHTO test methods. If an AASHTO test method is not available, the ASTM method will be used.

Table 5.4 Aggregate Material Test Methods

Characteristics	Test Method AASHTO	Test Method ASTM
Abrasion of Coarse Aggregate, Los Angeles Machine	T 96	C 131
Sieve Analysis, Fine and Course Aggregates	T 27	C 136
Unit Weight of Aggregate	T 19	C 29
Sand Equivalent	T 176	C 2419

➤➤ Materials

Asphalt. The asphalt shall be as specified by the engineer from Table 5.5 prior to letting the contract. The grade of asphalt material specified shall meet the requirements of the AASHTO and ASTM specifications listed in Table 5.5.

Table 5.5 Asphalt Materials

Asphalt Grade	Specification AASHTO	Specification ASTM
MC-250	M 82	D 2027
MC-800	M 82	D 2027
SC-250	- -	D 2026
SC-800	- -	D 2026
CMS-2	M 208	D 2397
CMS-2h	M 208	D 2397
HFMS-2s	M 140	D 977

For spray applications the engineer will specify the temperature at which the material shall be used.

Mineral Aggregate. The mineral aggregate shall be crushed stone, crushed or uncrushed gravel, slag, sand, stone screenings, mineral dust or a combination of these materials meeting one of the gradations shown below in Table 5.6.

Table 5.3 Mineral Aggregate Gradations

Sieve Size	Mix Designation and Nominal Maximum Size of Aggregate 9.5 mm (3/8 in.)	12.5 mm (1/2 in.)	19.0 mm (3/4 in.)
25.0 mm (1 in.)	—	—	100
19.0 mm (3/4 in.)	—	100	90-100
12.5 mm (1/2 in.)	100	90-100	—
9.5 mm (3/8 in.)	90-100	—	56-80
4.75 mm (No. 4)	55-85	44-74	35-65
2.36 mm (No. 8)	32-67	28-58	23-49
.300 mm (No. 50)	7-23	5-21	5-19
.075 mm (No. 200)	2-10	2-10	2-8

➤➤ *Construction*

Alternate 1-Travel Mixing. Coarse and fine aggregate shall be deposited in a single windrow in the proportions required to provide a total aggregate conforming with the gradation specified in the Mineral Aggregate section. Unless the travel mixer is equipped to measure and apply asphalt during the mixing operation, the windrow shall be flattened and the application shall be made with the asphalt distributor. The aggregate shall be free from visible moisture at the time of mixing. The asphalt shall be applied at the temperature and rate specified by the engineer to produce a final mixture containing from 4 to 6 percent cutback asphalt (7 to 10 percent asphalt emulsion) by weight of total mix. The mineral aggregate and the asphalt shall be mixed thoroughly.

Alternate 2-Blade Mixing. Coarse and fine mineral aggregate shall be deposited in a single windrow in the proportions required to provide a total aggregate conforming with the gradation specified specified in the Mineral Aggregate section. After the proportions of coarse and fine aggregate are adjusted, the total loose aggregate shall be mixed thoroughly with a motor grader. It shall then be bladed into a single truncated windrow of uniform cross-section for measurement and adjustment as may be directed by the engineer.

Immediately prior to application of the asphalt, the windrow of mixed aggregate shall be bladed to a uniform cross-section approximately 50 mm (2 in.) thick. If damp, it shall be bladed back and forth until surface dry. Upon the layer of graded aggregate, the asphalt shall be applied uniformly with the asphalt distributor at the temperature and at the rate specified. The aggregate and asphalt shall be mixed as described in the following paragraph. Successive applications of asphalt shall then be applied and mixed in the quantities, not exceeding 2.5 litres/m^2 (1/2 gal/yd^2) each.

The motor grader shall follow the distributor immediately after each application of asphalt and continue to operate on the treated strip until all free asphalt is mixed into the aggregate. After the aggregate has received its total application of asphalt, mixing shall continue until a thoroughly uniform mixture is produced. If, before the process is completed, the mixture should become wet, the mixing operation shall be continued until it dries out. After final mixing the material shall be brought to a single windrow.

Stockpiling. The finished mixture shall be windrowed or stockpiled on an approved storage space. When payment is to be made upon a cubic meter (yard) basis the stockpile shall be shaped to facilitate accurate volume measurement.

Method of Measurement. The quantities to be paid for will be the total number of tonnes (tons) or cubic metres (yards) of asphalt maintenance mixture delivered to the stockpile.

Basis of Payment. The quantities measured as described in the Method of Payment section will be paid for at the contract unit price bid for this item. Payment will be in full compensation for furnishing, mixing, hauling, and stockpiling the mixture and for all labor and use of equipment, tools, and incidentals necessary to complete the work in accordance with these specifications.

➤➤ *Important Notice to the Engineer*

Selection of Asphalt. This may be used as a guide for selecting the type and grade of asphalt for the stockpile mixture:

- MC-250 For immediate use under hot or moderate weather conditions, or for use within a short time after stockpiling
- MC-800 For use within short time after stockpiling
- SC-250 For long period storage in hot, dry climates
- SC-800 For long period storage
- CMS-2 Mix can be designed for use within a short time after stockpiling
- CMS-2h Mix can be designed for use within a short time after stockpiling
- HFMS-2s Mix can be designed for use within a short time after stockpiling or for long storage period

Amount of Asphalt. The asphalt requirements for the aggregate gradation specified in the Mineral Aggregate section will normally be in the range of 4 to 6 percent of cutback asphalt by weight of total mix (7 to 10 percent asphalt emulsion).

Equipment. The blade-mixing portion of these specifications is written to require a motor grader for the mixing process.

Temperature of Asphalt. Typical temperatures for uses of asphalt are shown in Tables 5.7 and 5.8.

Table 5.7 Typical Temperatures for Uses of Asphalt – Degrees Celsius (°C)

Type and Grade Of Asphalt	Pugmill Mixture Temperatures[1]		Spraying Temperatures[5]	
	Dense-Graded Mixes	Open-Graded Mixes	Road Mixes	Surface Treatments
Asphalt Cements				
AC-2.5	115-140	80-120	-	130+
AC-5	120-145	80-120	-	140+
AC-10	120-155	80-120	-	140+
AC-20	130-165	80-120	-	145+
AC-40	130-170	80-120	-	150+
AR-1000	105-135	80-120	-	135+
AR-2000	135-165	80-120	-	140+
AR-4000	135-165	80-120	-	145+
AR-8000	135-165	80-120	-	145+
AR-16000	150-175	80-120	-	-
200-300 pen.	115-150	80-120	-	130+
120-150 pen.	120-155	80-120	-	130+
85-100 pen.	120-165	80-120	-	140+
60-70 pen.	130-170	80-120	-	145+
40-50 pen.	130-175	80-120	-	150+
Emulsified Asphalts				
RS-1	-		-	20-60
RS-2	-		-	50-85
MS-1	10-70[2]		20-70	20-70
MS-2	10-70[2]		20-70	-
MS-2h	10-70[2]		20-70	-
HFMS-1	10-70[2]		20-70	20-70
HFMS-2	10-70[2]		20-70	-
HFMS-2h	10-70[2]		20-70	-
HFMS-2s	10-70[2]		20-70	-
SS-1	10-70[2]		20-70	-
SS-1h	10-70[2]		20-70	-
CRS-1	-		-	50-85
CRS-2	-		-	50-85
CMS-2	10-70[2]		20-70	-
CMS-2h	10-70[2]		20-70	-
CSS-1	10-70[2]		20-70	-
CSS-1h	10-70[2]		20-70	-
Cutback Asphalts (RC, MC, SC)[3]				
30(MC only)	-	-	-	30+
70	-	-	20+	50+
250	55-80[4]	-	40+	75+
800	75-100[4]	-	55+	95+
3000	80-115[4]	-	-	110+

NOTES: Exact conversions from °F rounded to nearest 5° C.
-Temperatures for asphalt cements and cutback asphalts are guides only
[1]Temperature of mixture immediately after discharge from the pugmill rather than temperature of asphalt cement or cutback asphalt.
[2]Temperature of the emulsified asphalt in the pugmill mixture.
[3]Application temperature may, in some cases, be above the flash point of the material. Caution must therefore be exercised to prevent fire or an explosion.
[4]Rapid-Curing (RC) grades are not recommended for hot pugmill mixing.
[5]The maximum temperature (asphalt cement and cutback asphalt) shall be below that at which fogging occurs.

Table 5.7 Typical Temperatures for Uses of Asphalt – Degrees Fahrenheit (°F)

Type and Grade Of Asphalt	Pugmill Mixture Temperatures[1]		Spraying Temperatures[5]	
	Dense-Graded Mixes	Open-Graded Mixes	Road Mixes	Surface Treatments
Asphalt Cements				
AC-2.5	235-280	180-250	-	270+
AC-5	250-295	180-250	-	280+
AC-10	250-315	180-250	-	280+
AC-20	265-330	180-250	-	295+
AC-40	270-340	180-250	-	300+
AR-1000	225-275	180-250	-	275+
AR-2000	275-325	180-250	-	285+
AR-4000	275-325	180-250	-	290+
AR-8000	275-325	180-250	-	295+
AR-16000	300-350	180-250	-	-
200-300 pen.	235-305	180-250	-	265+
120-150 pen.	245-310	180-250	-	270+
85-100 pen.	250-325	180-250	-	280+
60-70 pen.	265-335	180-250	-	295+
40-50 pen.	270-350	180-250	-	300+
Emulsified Asphalts				
RS-1	-		-	70-140
RS-2	-		-	125-185
MS-1	50-160[2]		70-160	70-160
MS-2	50-160[2]		70-160	-
MS-2h	50-160[2]		70-160	-
HFMS-1	50-160[2]		70-160	70-160
HFMS-2	50-160[2]		70-160	-
HFMS-2h	50-160[2]		70-160	-
HFMS-2s	50-160[2]		70-160	-
SS-1	50-160[2]		70-160	-
SS-1h	50-160[2]		70-160	-
CRS-1	-		-	125-185
CRS-2	-		-	125-185
CMS-2	50-160[2]		70-160	-
CMS-2h	50-160[2]		70-160	-
CSS-1	50-160[2]		70-160	-
CSS-1h	50-160[2]		70-160	-
Cutback Asphalts (RC, MC, SC)[3]				
30(MC only)	-	-	-	85+
70	-	-	65+	120+
250	135-175[4]	-	105+	165+
800	165-210[4]	-	135+	200+
3000	180-240[4]	-	-	230+

NOTES:
-Temperatures for asphalt cements and cutback asphalts are guides only
[1]Temperature of mixture immediately after discharge from the pugmill rather than temperature of asphalt cement or cutback asphalt.
[2]Temperature of the emulsified asphalt in the pugmill mixture.
[3]Application temperature may, in some cases, be above the flash point of the material. Caution must therefore be exercised to prevent fire or an explosion.
[4]Rapid-Curing (RC) grades are not recommended for hot pugmill mixing.
[5]The maximum temperature (asphalt cement and cutback asphalt) shall be below that at which fogging occurs.

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832 LOAD, HAUL, AND PLACE MATERIALS

832.01
Service Required

Load, haul, and place material at designated sites.

832.02
Performance Standard

Loading, hauling, and placing is complete when no obstruction remains in or adjacent to the roadway or in ditches which would have the potential to interfere with traffic use, block or divert water from structures or channels. This includes relocation, repositioning, stabilization, and revegetation as ordered by the Contracting Officer.

832.03
Location of Work

As specified on roads listed on the ROAD LISTING, SHOWN ON THE PLANS, or as ordered by the Contracting Officer.

832.04
Measurement

Measurement under this Section will be made by the total number of units for each item listed in the SCHEDULE OF ITEMS completed and accepted.

A. Cubic Yard: The quantity will be the number of cubic yards measured in the vehicles.

B. Mile: Work activity will be measured along the centerline of the road regardless of the number of lanes.

832.05
Payment

A. The accepted quantities will be paid at the contract price per unit of measurement for the Section 832 pay items listed in the schedule of items. Payment will be full compensation for the work prescribed in this Section.

Pay Item	Pay Unit
832(1) Load, Haul, and Place Material	Cubic Yard
832(2) Load, Haul, and Place Material	Mile
832(3) Load, Haul, and Place Material	Lump Sum

832.06

Acceptable Quality Levels

Description	Major Defect	Minor Defect	Allowable Defects		Required Action	
			Major	Minor	Major	Minor
Slopes	Unstable material left on slopes	Material left on slopes that can be stabilized and won't block drainages	0	0	Remove	Remove or stabilize in place
Backslopes	Undercut backslope will result in destabilization of slope	Undercut backslope will not result in destabilization of slope	0	0	Repair and Stabilize	Revegetate if greater than 0 minor defects
Ditches, inlet/outlet channels, streams and catch basins	Water will be diverted out of the drainage structure or soil enters system	< 20% impeded, but water will stay in the channel.	0	0	Rework	Rework if greater than 0 minor defects
Debris on Road (ML 4-5)	Any debris in traveled way	Debris in traveled way that may slow or impede traffic.	0	0	Rework	Rework if greater than 0 minor defects
Debris on Road (ML 3)	Debris in traveled way that may impede traffic.	Debris in traveled way that may slow traffic.	0	0	Rework	Rework if greater than 0 minor defects
Debris on Road (ML 2)	Objects in traveled way that obstruct high clearance vehicles	Debris in traveled way that may impede high clearance vehicles	0	0	Rework	Rework if greater than 0 minor defects
Placed Material (Disposal Sites)	Unstable material on designated sites.	N/A	0	N/A	Stabilize	N/A
Revegetation	No revegetation work done	Revegetation work incomplete	0	0	Rework if greater than 0 minor defects	Rework if greater than 0 minor defects
Work Area Management	Not following approved safety plan which may include signs, flaggers, and other temporary traffic control measures	Not following approved safety plan which may include signs, flaggers, and other temporary traffic control measures	0	0	Suspend work until in compliance	Suspend work until in compliance

SPECIAL PROJECT SPECIFICATION (01/15)
881-F1 MOBILIZATION / EQUIPMENT MOVING

881.01
Service Required

A. Mobilization of personnel, equipment, and material to the project site.

B. Moving of equipment outside the established work schedule as ordered.

881.02
Performance Standards

Equipment shall be clean and weed free prior to moving it to the project area. This cleaning shall remove all soil, plant parts, seeds, vegetative matter, or other debris that could contain or hold seeds. All subsequent move-ins of equipment to the project area shall be treated in the same manner as the initial move-in. Equipment shall be considered free of soil, seed, and other such debris when a visual inspection does not disclose such material. This requirement does not apply to service vehicles, water trucks, pickups, cars, and/or similar vehicles.

Additional equipment washing is applicable to all equipment on site requiring washing, NOT individual pieces of equipment.

Unless otherwise agreed, the Forest Service shall be given a minimum of 24 hours notice when equipment is ready for inspection. Notification will include an agreed upon location where the equipment will be available for inspection by the Forest Service. Inspection will be required after every cleaning.

Subsequent equipment moving mileage is defined as a one way moving distance above 10 miles from the present work site to the ordered work site. Moving is complete, when the contractor has moved from the present work site to the ordered work site and returned to the previous location.

881.03
Location of Work:

As specified on roads listed on the ROAD LISTING, SHOWN ON THE PLANS, or as ordered by the Contracting Officer.

881.05
Payment

A. The accepted quantities will be paid at the contract price per unit of measurement for the Section 881 pay items listed in the schedule of items. Mobilization is complete when all equipment, personnel, and materials are moved to the project site and work has been started. Payment will be full compensation for the work prescribed in this Section.

Pay Item		Pay Unit
881(1)	Mobilization	Lump Sum
881(2)	Mobilization	Each
881(3)	Equipment Moving	Miles

881.06
Acceptable Quality Levels

Description	Major Defect	Minor Defect	Allowable Defects		Required Action	
			Major	Minor	Major	Minor
Weed free equipment	**Equipment not weed free.**	**N/A**	**0**	**N/A**	**Equipment rejected until it can be made weed free**	**N/A**
Ordered Movement of Equipment	**Equipment not moved within designated time**	**N/A**	**1**	**N/A**	**Reduce unit cost by 10% for 1 week of time over designated time**	**N/A**
Equipment meets all state and federal regulations	**Does not meet state and federal regulations**	**N/A**	**0**	**N/A**	**Bring equipment up to state and federal regulations or replace equipment**	**N/A**
Equipment leaks	**Equipment leaks in sensitive areas or leaks that are large and not typically inherent in the specific equipment**	**Small leaks inherent in the specific type equipment**	**0**	**N/A**	**Replace equipment and restore affected site as directed by the Contracting Officer**	**Place absorbent pads under equipment when not operating.**