

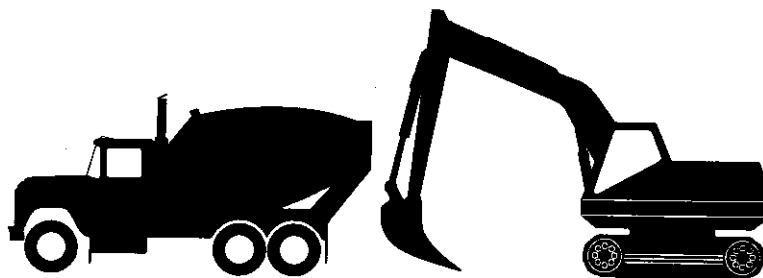


HUD MAINTENANCE GUIDEBOOKS

GUIDEBOOK

3

PAVEMENT MAINTENANCE



September 1995

HUD MAINTENANCE GUIDEBOOKS

GUIDEBOOK THREE

PAVEMENT MAINTENANCE

Department of Housing and Urban Development
Office of Public and Indian Housing

September 1995

HUD Maintenance Guidebook Three - Pavement Maintenance

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**TABLE OF CONTENTS
FOR
HUD MAINTENANCE GUIDEBOOKS
GUIDEBOOK III - PAVEMENT MAINTENANCE**

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CHAPTERS	Pages
1 GENERAL	
A Introduction	1-1
B General Standards and References	1-1
C Safety	1-2
D Permits	1-3
E Environmental Issues	1-3
2 PAVEMENT MAINTENANCE PROCEDURES	
A Introduction	2-1
B General Pavement Maintenance and Repair	2-2
3 BITUMINOUS PAVEMENTS	
A Bituminous Pavement Construction Types	3-1
B Bituminous-Asphalt Materials	3-2
C Recommended Repairs to Correct Deficiencies	3-6
4 CONCRETE PAVEMENTS	
A Concrete Pavement Construction Types	4-1
B Pavement Materials	4-2
C Weather Considerations	4-5
D Forming, Placing, and Finishing	4-7
E Finishes	4-8
F Recommended Maintenance to Correct Deficiencies	4-9
5 APPURTENANT FACILITIES	
A Definition	5-1
GLOSSARY	G-1

END OF TABLE OF CONTENTS

MAINTENANCE GUIDEBOOK III - PAVEMENT MAINTENANCE

CHAPTER ONE - GENERAL

SECTION A INTRODUCTION

The purpose of this Guidebook is to assist public housing agencies and Indian housing authorities (jointly referred to as HAs) in keeping all paved areas of their developments in good condition in order to prevent or delay major repair expenses. References to paved areas or pavements include, but are not necessarily limited to, streets, alleys, drives, parking areas, walks, drying yards, recreation and play areas, and other paved surfaces which HAs maintain.

Pavement maintenance includes, but is not limited to, keeping the paved surfaces clean, attractive in appearance, and free from surface irregularities such as small cracks and joint defects, which normally lead to greater deterioration. Efficient and timely maintenance repairs are economical and will do much to keep the paved surfaces attractive and in a safe condition.

Water and frost are the most frequent causes of serious pavement failure. Once the pavement surface has cracked or otherwise failed, permitting the entry of water into the sub-base, deterioration is greatly accelerated. Neglecting the repair of such defects invites progressive damage resulting in expensive repairs at a later date. HAs, therefore, should take preventive measures to repair the defects promptly in order to minimize future maintenance expenses. Shoddy maintenance is almost as bad as none at all, and will prove costly in the long run.

The preventive maintenance and related repair methods discussed in this Guidebook include sealing and repairing pavement damage and correcting drainage failures. These activities can be carried out by an HA's maintenance personnel. Extraordinary repairs of large paved areas, or complex drainage problems requiring specially trained crews and heavy equipment, should be done by contract or, where possible, by arrangements with the local governmental (city, county, or state) maintenance departments.

SECTION B GENERAL STANDARDS AND REFERENCES

The general standards and references which relate to the maintenance of paved areas include an assortment of national and local standards which may be used for specific material requirements as well as detailed work methods and general equipment requirements. National standards include:

- ASTM - American Society of Testing and Materials, 1916 Race Street, Philadelphia, PA 19103;
- ACI - American Concrete Institute, PO Box 19150, Detroit, MI 48219;
- Asphalt Institute Publications - Research Park Drive, PO Box 14052, Lexington, KY 40512-4052;

- BOCA - Building Officials and Code Administrators, 4051 West Flossmoor Road, Country Club Hills, IL 60478-5795;
- ANSI - American National Standards Institute, 11 West 42nd Street, New York, New York 10036.

The above references are national in scope. However, it is better to use local references which include state and municipal standards developed for bituminous and concrete pavement construction, ranging from resurfacing to emergency concrete repairs. These local standards will include:

- State Highway Department specifications;
- City, county, or municipal specifications.

In most cases, where actual mix designs or substantial quantities of materials are required (for instance, for large overlays or slurry projects), the appropriate local material specifications should be used, where possible, since the concrete and bituminous material supplier will be familiar with the applicable mix design requirements.

SECTION C SAFETY

Key aspects of ensuring safety during maintenance activities include:

- Protecting pedestrians;
- Maintaining vehicular traffic;
- Avoiding utilities.

1. PEDESTRIANS

Work areas should be adequately marked to keep pedestrians out of areas where maintenance work is done. Special care should be exercised in areas of open excavation or abrupt changes in surfaces to direct pedestrians away from these hazards.

2. VEHICLES

A "Manual of Uniform Traffic Control Devices" (MUTCD) has been published for many years and is the official traffic-control document for practically all jurisdictions for maintaining safe traffic flow within work zones. The manual, which is updated periodically, deals with the signing and marking of construction projects exposed to traffic. This manual should be available in the HA's reference library, and may be ordered from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

3. UTILITY NOTIFICATIONS

If a maintenance activity requires excavation in areas where utilities are known or suspected to exist, the local utility companies or the local utility coordinator (such as Miss Utility) should be called before scheduling the work. Telephone and cable TV cables are installed at shallow depths and are easily cut or damaged. Gas and water connections to residences are also sometimes very close to the surface.

SECTION D PERMITS

There may be times when the boundaries of the pavement being maintained are not clearly defined. Most public streets and alleys in and around a development are owned and maintained by the local governing body such as the city, county, or state. Check with the local roadway or highway agency if you have any questions as to the ownership of paved areas for which the HA is responsible.

Sometimes a permit or other approval is required to do certain types of work, but this is rare in maintenance work. Where the pavement to be repaired is located beyond the property line or adjacent to pavement owned by others (state and local highway departments), a permit may be required before work can commence. This permit is designated as a "temporary access permit" and can be acquired within a very short time.

SECTION E ENVIRONMENTAL ISSUES

In planning maintenance for pavement repairs, two key environmental issues must be reviewed and addressed when applicable. These environmental issues are:

- Sediment and erosion control;
- Removal and disposal of potentially hazardous materials.

1. SEDIMENT AND EROSION CONTROL

When pavement maintenance and repairs require excavation and exposing soils which are subject to erosion, the sediment and erosion should be controlled by silt fences, berms, straw bales, and temporary sediment-control traps or ponds where large disturbed areas are involved. The state or local soil-conservation service provides standard details and specifications for acceptable methods of controlling sediments and erosion. Check with the local soil service or bureau for specific details or other requirements which may apply to the maintenance work.

2. HAZARDOUS MATERIALS (HYDROCARBONS AND PETROLEUM PRODUCTS)

Hydrocarbons and petroleum products, the basic components of bituminous pavement, are classified as hazardous materials. The disposal of asphalt paving materials or soils contaminated with hydrocarbons must be accomplished in a manner which complies with federal and state regulations. These potentially hazardous materials may be encountered while removing or repairing underground tanks.

END OF CHAPTER ONE

MAINTENANCE GUIDEBOOK III - PAVEMENT MAINTENANCE CHAPTER TWO - PAVEMENT MAINTENANCE PROCEDURES

SECTION A INTRODUCTION

Preventive maintenance extends the useful life of pavement. To accomplish this, the pavements should be inspected and maintained. The basic steps involve:

- Inspecting pavements;
- Reporting deficiencies;
- Scheduling maintenance activities/Issuing work orders;
- Performing preventive maintenance/Inspecting completed work;
- Monitoring results.

These steps should be performed in a continuous cycle to guarantee the success of a preventive pavement maintenance program.

1. INSPECTION

In accordance with the Public Housing Management Assessment Program (PHMAP) requirements, all paved surfaces, including roadways, sidewalks, parking lots, dumpster pads, and play and game areas, should be inspected on an annual basis. For this purpose, a standard checklist should be developed (see sample, page 2-3). If available, a personal computer (PC) should be used. A checklist and a copy of the development plan identifying all paved areas should be taken along during the inspection. Detailed notes, sketches, and related inspection findings which complement and expand upon the checklist should be made directly on the development plan. Each annual inspection should utilize a new copy of the development plans so that the results can be compared with previous inspections. (In addition, a master copy of the development plan should note all repairs and the reinspection dates when repairs and preventive maintenance were performed). An assortment of off-the-shelf software is now available for PC applications related to pavement-maintenance programs.

2. REPORTING

Deficiencies noted during the inspection should be developed into a report which logically groups the various pavement types, identifies the deficiencies, and prioritizes the necessary repairs. The urgency rating for prioritizing the repairs or preventive maintenance tasks may be rated as follows:

- 5 - No repairs are necessary. Schedule only annual preventive maintenance.
- 4 - Schedule for maintenance next year (minor deficiency).
- 3 - Schedule for maintenance this year.

- 2 - Schedule for immediate maintenance.
- 1 - Schedule emergency repairs (by maintenance staff or contractor).
- 0 - Cannot be repaired without major contract.

3. SCHEDULING

Based on the preventive-maintenance program and the reported deficiencies of the inspection, a work schedule should be developed. The schedule should take into account the priority of maintenance and repair activities, and the estimated time and costs for each. Scheduling should also take into consideration seasonal factors such as special measures required for working in extreme temperatures.

4. PREVENTIVE MAINTENANCE

Preventive maintenance requires a minimum amount of time, money, and resources if completed on time. It includes:

- Sealing joints and cracks;
- Applying a seal coat;
- Providing positive drainage;
- Maintaining edging or other structural supports which confine the pavement.

5. MONITORING

This last step is an essential part of preventive maintenance. The HA evaluates the efficiency of the program and its implementation, updates the related records, and plans for any necessary corrective action and budgeting.

SECTION B GENERAL PAVEMENT MAINTENANCE AND REPAIR

All pavements require maintenance. Good maintenance practice involves preventive maintenance, with an emphasis on taking timely action to repair any deterioration. The intent of preventive maintenance is to keep the pavement in the best possible condition in order to extend its lifetime and avoid expensive repairs. Specific preventive maintenance activities include:

- Sealing joints and cracks;
- Providing proper drainage;
- Applying seal coats.

The easiest way to assure that the pavement is maintained properly is to develop an annual program based

PAVEMENT INSPECTION CHECKLIST

INSPECTOR NAME: _____

DATE OF INSPECTION: _____

PAVEMENT LOCATION: _____

PAVEMENT TYPE	CONDITION RATING	URGENCY RATING	COMMENTS
GENERAL APPEARANCE			
CLEANLINESS			
BITUMINOUS PAVEMENT			
Shrinkage and Localized Cracking			
Longitudinal and Transverse Cracking			
Ravelling/Abrasion/Pitting			
Rutting			
Shoving			
Edge Failure			
Potholes/Pavement Failure			
Ponding/Poor Drainage			
Requires Sealing			
CONCRETE			
Longitudinal/Transverse Cracking			
Spalling			
Scaling			
Crazing/Map Cracking			
Failed/Disintegrated Areas			

CONDITION RATINGS:

- 5 - *Excellent condition, no defects*
- 4 - *Very good condition, minor deficiencies*
- 3 - *Good condition, 10 -25% of pavement has minor deficiencies*
- 2 - *Fair condition, 25 - 50% of pavement has minor or major deficiencies*
- 1 - *Poor condition, over 50% of pavement is distressed*
- 0 - *Failure, pavement no longer functions.*

URGENCY RATINGS:

- 5 - *No scheduled repairs necessary, only annual preventive maintenance activities*
- 4 - *Schedule for maintenance next year, minor deficiency*
- 3 - *Schedule for maintenance this year*
- 2 - *Schedule for immediate maintenance*
- 1 - *Schedule emergency repairs (maintenance or contractor)*
- 0 - *Cannot be repaired without major contract.*

on inspections. Such a program should enable the HA to budget the work to be done either by the HA or by a contractor. A good program assures that pavements will be inspected at least on an annual basis, as required by the Public Housing Management Assessment Program (PHMAP) of the Department of Housing and Urban Development. However, semi-annual inspections are more desirable, especially in areas where there are seasons of extreme weather conditions. In the latter case, the inspection should be conducted before major seasonal changes. This will allow time to make repairs such as sealing cracks and correcting base failures. A second inspection should be made as soon as possible, after the seasonal change, in order to promptly repair the pavement damages resultant from extreme heat or cold. In addition to seasonal considerations, maintenance personnel should always be alert for the first indication of any pavement defect (for example, damage resulting from excessive truck wheel loads) so that timely repairs can be made.

1. SEASONAL CONSIDERATIONS

The time of the year when pavement maintenance work takes place has considerable bearing on the procedures for making repairs, particularly patching. In summer, even a coarse-textured asphalt patch will gradually set under traffic and warm weather, while the same patch might fail within a day or so if placed in freezing winter conditions. It is easier to make and protect repairs of concrete pavement in warm weather than during freezing winter months. This does not mean that pavement failures should be ignored in the winter. When a continuing series of freezing and thawing cycles occur, be prepared to repair potholes. Potholes, which occur in both asphalt and concrete pavements in spite of good maintenance practices, should be repaired immediately, at least on a temporary basis. Several products are available to prevent progressive failures until weather conditions permit permanent repairs.

2. TYPICAL PAVEMENT STRUCTURE

Before going into a detailed discussion of maintenance practices, the underlying strengths or weaknesses of pavement should be explained. Any pavement, whether built for vehicular, pedestrian, or recreational purposes, consists of subbase, base, and surface courses (see Figure 2-1). The subbase is undisturbed or compacted soils, the base normally consists of gravel or crushed stone, and the surface course, called the wearing course, is the concrete or bituminous asphalt pavement built on top of the base. Bituminous asphalt pavement is occasionally comprised of a wearing and binder course.

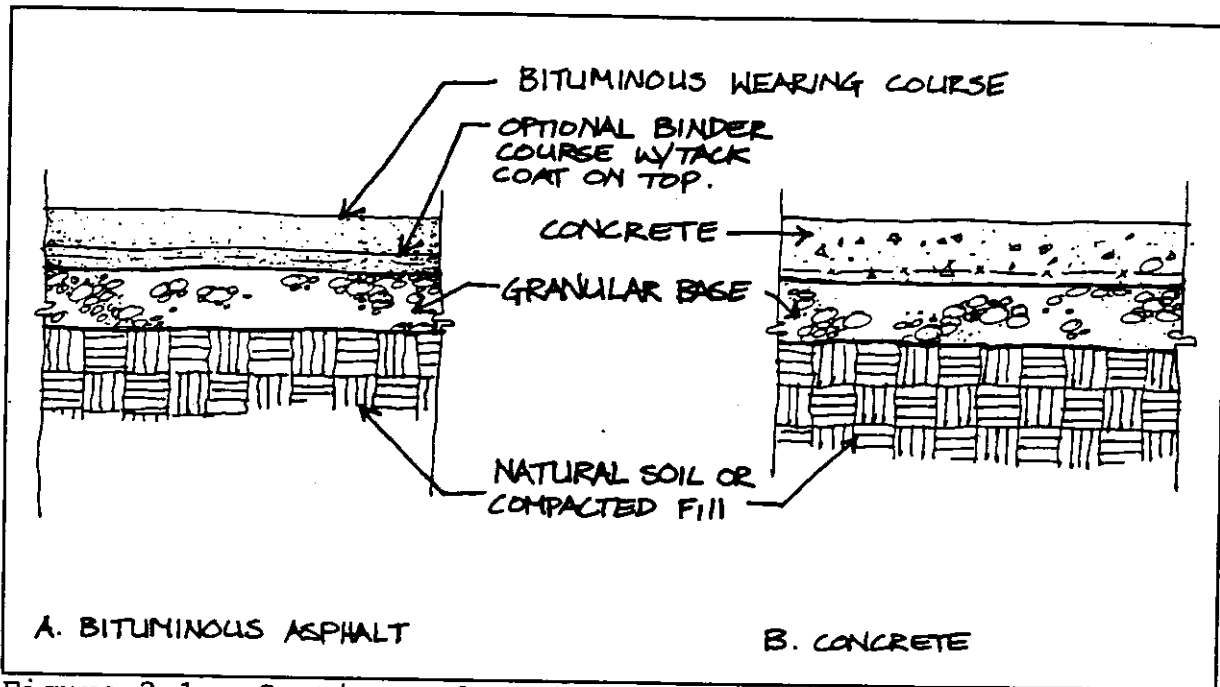


Figure 2-1: Sections of Typical Pavement Structure

3. CAUSES OF PAVEMENT FAILURE

The most common cause of pavement failure is the intrusion of water below the pavement, which may result from inadequate drainage. Other causes may include cracked or otherwise damaged pavements, insufficient base thickness, or an unstable subbase. Any break or crack in the pavement permits water to saturate the subbase, which is no longer able to support the loads. During periods of below-freezing temperatures, water and moisture become solid ice and, while expanding, cause pavement failure. Therefore, it is necessary that the subbase be kept dry and well drained in order to retain its stability.

As soon as pavement begins showing signs of deterioration, such as settlement and disintegration, an inspection should be made to determine the cause, and proper actions should be taken to correct the defects.

4. MAKING A PERMANENT PATCH

A patch should be made so that its strength, quality, and appearance will equal that of the remainder of the pavement. Specific patching materials are discussed in later chapters for bituminous and concrete pavements, as are details for their placement. The sequence of steps in making a patch is illustrated in Figure 2-2.

a. Cleaning and Preparation

The secret of a good repair job is thorough cleaning of the affected area and proper preparation of it to receive the repair materials. Following are recommendations for preparing various components of the pavement, including the subbase, base, and surface.

b. Replacing the Subbase

Prior to replacing the subbase, all soft, wet, unstable, loose, and undesirable materials should be removed. New, dry subbase material should be installed and thoroughly compacted. Where it is necessary to remove excess water from the subbase, appropriate drains should be installed.

c. Replacing the Base Course

After removing all unsuitable subbase and base course materials, including rock and gravel, the surrounding base material should be cleaned and prepared so that the new base can establish a good bond to the existing base. The new base course should match the existing base material (whether gravel, crushed stone, or concrete) and should be thoroughly compacted.

d. Replacing the Surface Pavement

When replacing the surface or wearing course for either bituminous or concrete pavements, the base should be swept clean and free of dust, dirt, loose rock, gravel, or other unsuitable material. The surrounding vertical surfaces should be properly prepared to establish a good bond with the new material. The new surface material may be concrete or a bituminous material, depending on the pavement type.

e. Applying the Seal Coat

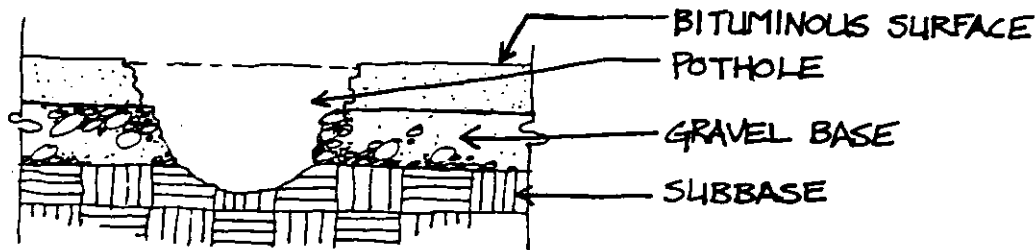
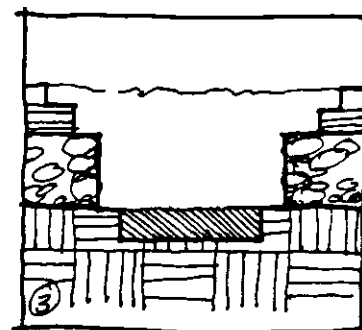
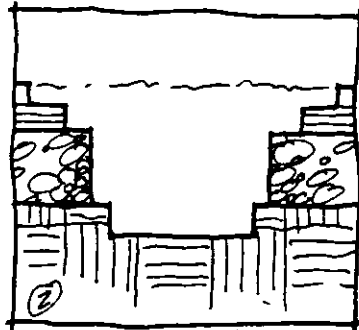
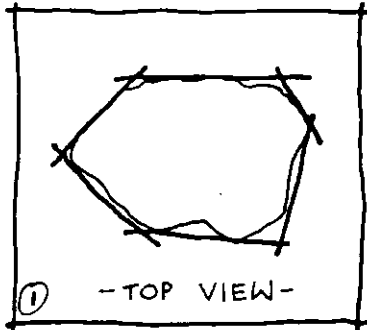
Prior to application of the seal coat or a leveling course, the pavement should be thoroughly cleaned. All dirt, dust, and loose material should be removed from the surface, cracks, and pits by sweeping with a broom and then flushing with clean water or compressed air. Oil and grease should be removed by scrubbing the affected areas with a nonfoaming detergent such as a solution of trisodium phosphate (mixed 1 cup trisodium phosphate to 1 gallon water). The surface should be flushed thoroughly with clean water to remove all of the cleaning solution.

During flushing, depressions and low areas will be filled with water. Mark the edge of each puddle with chalk on the pavement. These marks may be used for designating the limits of a leveling

MARK AND CUT EDGES OF POTHOLE IN STRAIGHT LINES ON TOP OF PAVEMENT.

REMOVE UNSUITABLE MATERIALS FROM POTHOLE AND TRIM & CLEAN EDGES OF EACH COURSE TO VERTICAL SURFACES.

REPLACE SUBBASE WITH DRY MATERIAL AND COMPACT THOROUGHLY.



REPLACE BASE COURSE TO MATCH EXISTING AND COMPACT THOROUGHLY.

PRIME TOP OF NEW BASE COURSE AND PAINT EDGES WITH EMULSION-TYPE SEALER.

PLACE PATCH BY COMPACTING IN LAYERS (1 1/2" MAX) TO MATCH EXISTING SURFACE & APPLY SEAL COAT TO COVER ALL JOINTS.

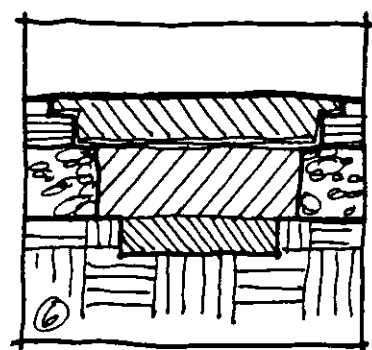
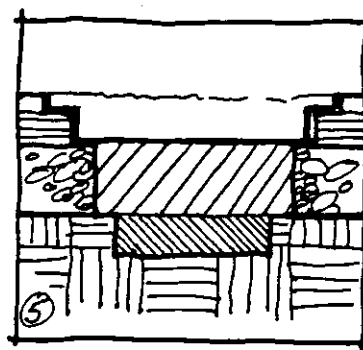
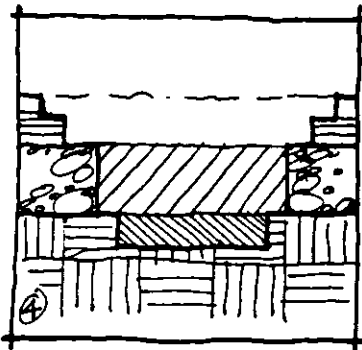


Figure 2-2: Steps in Making a Permanent Patch

course. In addition, by measuring the depth of water, the quantity of fill material required can be estimated. The water should then be swept from the puddle.

If a leveling course is to be installed, the area to be leveled should receive a "tack" coat.

especially if the leveling course is thin, because thin asphalt courses are very susceptible to delamination in the winter. The tack coat should be very thin (fogged).

5. LOW-TYPE PAVEMENTS AND DUST CONTROL

In addition to the bituminous and concrete pavements covered in this guidebook, some HAs may have low-type pavements to maintain.

a. Low-Type Pavements

These are pavements in which natural soils, selected soils, and mineral aggregates are used separately or in combination. They may be classified by the type of materials composing the surface area, such as natural soil, sand-clay, and coarse graded aggregate. Failures of these pavements are due to poor drainage, improper grading, inadequate compaction, and unsuitable materials. Repairs should be made promptly to correct any of the above conditions by removing unstable material, filling depressions and other surface irregularities with materials similar to surface materials, compacting into place, and smoothing and shaping the surfaces to drain.

b. Dust Control

During dry weather, dust from low-type pavements can be a nuisance. It can be controlled by frequently spraying with water. The application of too much water, however, should be avoided, since it has a tendency to cause soft spots. Calcium chloride may also be applied. Calcium chloride is a chemical salt that attracts moisture from the air, and settles the dust. It may be used either in flake form or dissolved in water. When used in flake form, it should be spread evenly over the surface at the rate of approximately one pound per square yard. This may be done by hand or with a mechanical sower such as a seed sower. Applied at night, calcium chloride absorbs moisture from the air more quickly than by day.

When used in solution, a maximum of four pounds of calcium chloride dissolved in a gallon of water is spread by sprinkling at the rate of a pint to a quart per square yard. It is best to moisten dry surfaces during daytime operations. Since it is soluble in water, it may be washed away by rain, and needs to be replaced periodically. Calcium chloride should not be used on sticky clay, since it makes a slippery mess if the road surface contains insufficient coarse aggregate.

6. UTILITY CUTS

Cuts made by utility companies in pavement owned by HAs are necessary to allow access to utility lines. However, these cuts should be done following a process set up by the HA. The HA should identify the location and specify the work to be done, the type of materials to be used, how the work is to be done, the hours in which the work may be done, and how traffic is to be managed.

The HA should ensure that the work is completed in accordance with the established process and sound construction practice. The cut in the pavement and its base should be approximately six inches wider than the utility trench on each side. Selected material should be used for backfill, which should be compacted in 6" layers and brought up to the top of the subbase. Utility cuts are notorious for settling even when the construction has met all specifications. Any settlement of the subgrade will leave a void under the patch. Heavy loads crossing over the patch will cause it to crack and eventually fail. Because settlement is such a problem, some jurisdictions allow a utility cut in a concrete road to be patched with bituminous material. When the patch settles, it is brought to grade level by adding more bituminous material.

END OF CHAPTER TWO

MAINTENANCE GUIDEBOOK III - PAVEMENT MAINTENANCE

CHAPTER THREE - BITUMINOUS PAVEMENTS

SECTION A BITUMINOUS PAVEMENT CONSTRUCTION TYPES

1. APPLICATION OF BITUMINOUS PAVEMENT

The predominant uses for bituminous pavements are roadways and parking lots; however, such pavements are also used for playgrounds, basketball courts, and pedestrian walkways. Bituminous pavements for roadways and parking lots are designed to sustain the heavy loads of cars and trucks, but those used in recreational and pedestrian areas do not require as much structural strength.

All pavements have certain common features related to their construction. Whether built for vehicular, pedestrian, or recreational uses, they consist of subbase, base, and surface course. Variations in the depth and types of materials required for a given pavement will dictate the pavement's ability to handle adequately the intended loads, ranging from heavily loaded vehicular traffic to light foot traffic. Figure 3-1 shows a typical section for bituminous pavement.

2. TYPES OF FAILURES

Numerous types of failures may be encountered in a bituminous pavement structure. The first signs of failures show up on the pavement surface. Typical defects found in bituminous pavements and their causes include:

- **Lane or shoulder dropoff:** a difference in elevation of the lane adjacent to the shoulder caused by settlement or erosion of the shoulder material.
- **Bleeding:** a black film on the surface of the pavement caused by excessive liquid asphalt in the mix or poor gradation of the mix.
- **Bumps and sags:** upward displacement of the pavement caused by frost heaves, traffic loads, or concrete slab buckling under a bituminous pavement overlay.
- **Rutting:** a depression in the wheel paths resulting from poor compaction of the subgrade or a weak mix.
- **Shoving:** permanent longitudinal displacement of the pavement caused by heavy loads and/or heavy vehicles braking or turning.
- **Swell:** upward rise in the pavement caused by swelling soil (usually clay) or growth of tree roots.
- **Raveling or weathering:** wearing away of the pavement caused by loss of liquid asphalt and fine aggregate in the pavement.
- **Pothole:** local depression caused by the thawing of ice accumulated in the subbase.

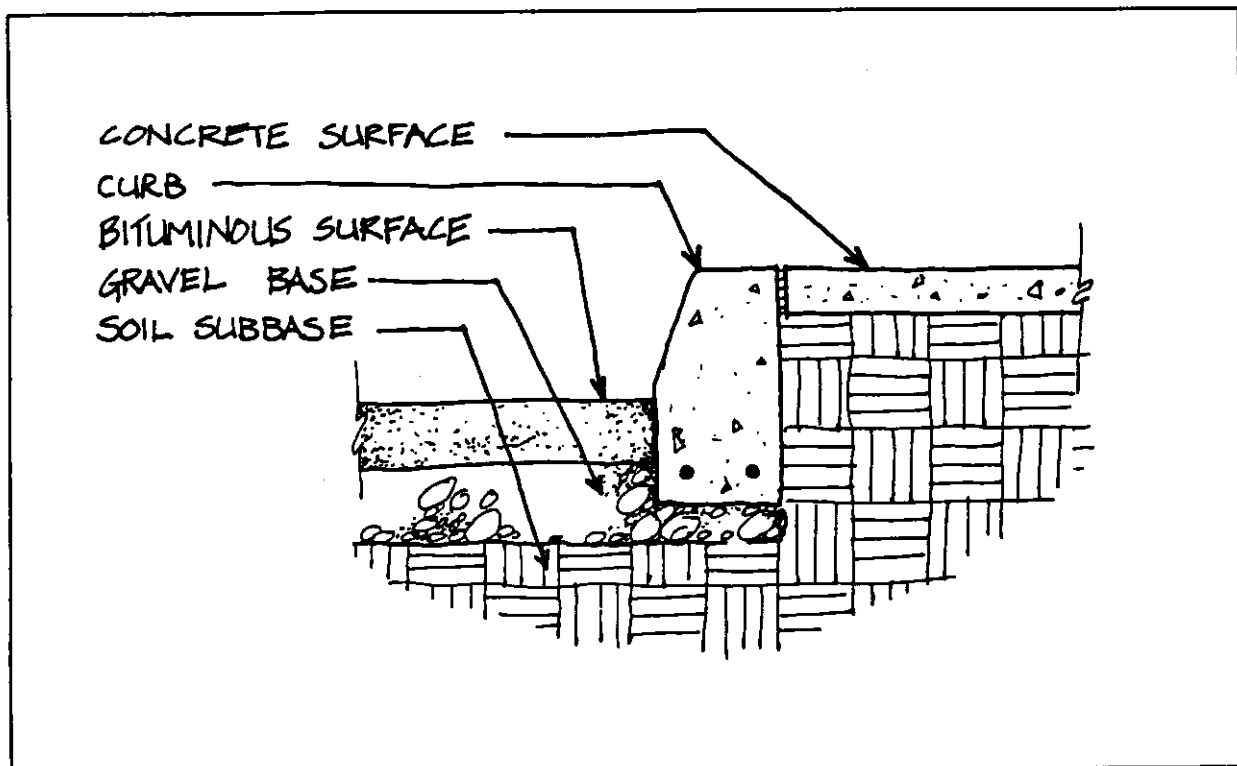


Figure 3-1: Typical Bituminous Pavement Section

SECTION B BITUMINOUS-ASPHALT MATERIALS

The primers, seal coats, or sealers and patching mixes described in this manual are materials primarily designed and formulated for use in repairing and maintaining bituminous pavements. There are many locally supplied products for bituminous pavement maintenance and repairs. Local suppliers should be contacted to obtain these products or their equals. The suppliers employ or have access to technical representatives who have up-to-date information on such products and their applications. It is recommended that HAs periodically contact the suppliers for such information.

Asphalt products will not adhere to coal-tar pitch, nor will coal-tar pitch products stick to asphalt; they are incompatible. However, asphalt emulsions and tar emulsions will adhere to both asphalt and coal-tar pitch, and are recommended.

Ready-to-use primers and sealers are basically water emulsions, which require no heating and are easily applied by maintenance crews. *However, before opening any container and applying its contents, the manufacturer's directions should be carefully read and followed.* All water-emulsion products should be stored where they will not be subject to freezing and applied only when the temperature is above 45°F. Since they are water soluble, they should not be applied in the rain or when rain is expected.

1. PRIME COAT

A prime coat is a free-flowing liquid bituminous material applied to a pavement surface, commonly in the construction of roads. Priming waterproofs the surface, plugs capillary voids, coats and bonds loose particles, and promotes adhesion with the new surface course. A prime coat, which is applied with an asphalt distributor, is not used often for patch repairs, although it is effective for patching small areas where the surface of the base is extremely dry.

2. EASY-FLOW EMULSION-TYPE SEAL COATS OR SEALERS

The bituminous surface to be treated or given a seal must be clean of all dust, dirt, loose materials, oil, and grease. If oil or grease are or have been present, the surface should be thoroughly washed with a nonfoaming detergent such as trisodium phosphate (mix 1 cup to 1 gallon of water).

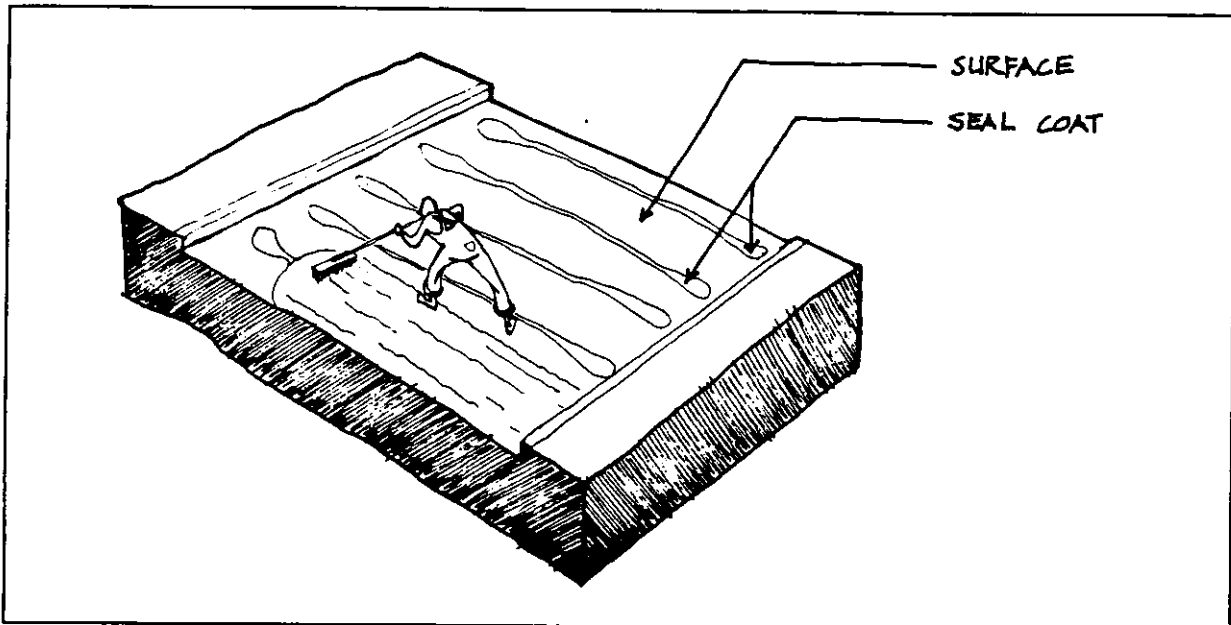


Figure 3-2: Applying and Spreading Seal Coat

Stir the sealer until it is of uniform color and consistency. Should it require thinning, add clean water according to the directions on the container, and stir it again until the material is uniform. Pour a small amount of the sealer on the pavement surface in parallel lines and spread it with a broom or rubber-faced squeegee. (See Figure 3-2) A smooth finish with a puddle- and ridge-free surface should result. The rate of coverage will vary from 75 to 100 square feet per gallon of sealer, depending upon the porosity and roughness of the surface to be treated. The surface must be thoroughly dry before being opened to either pedestrian or vehicular traffic. As soon as the work is completed, all tools should be cleaned by washing with water or petroleum solvent.

3. COAL-TAR PITCH EMULSION OR SYNTHETIC-RUBBER MODIFIED TAR OR ASPHALT-EMULSION SEAL COAT OR SEALER

These materials are formulated for use in deteriorated areas damaged by spillage of petroleum products. They dry to a uniform black color. When thoroughly dry, they are water-resistant, wear well, and can maintain abrasive and antiskid surfaces under traffic. They are also adaptable to an admixture of sand for skin patches. They are applied in the same manner as the heavy-bodied emulsion sealers. A manufacturer's technical representative should be contacted for advice regarding construction procedures and proportioning of abrasives.

4. HEAVY-BODIED EMULSION SEAL COAT OR SEALERS

The coal-tar pitch emulsion, synthetic-rubber modified tar or asphalt emulsion, and the heavy-bodied emulsion seal coat are applied in the same manner—a two-coat process. The surface should be repaired where necessary and thoroughly cleaned. For the first coat, mix the material thoroughly until it is uniform in color and consistency. A sealer for the first coat should be made by thinning or diluting one part of the material with one part of clean water, and stirred again until the mix is uniform and flows readily.

The first coat or seal coat should be poured in parallel lines on a damp, not wet, surface, then spread evenly with a soft-bristle nylon broom or a rubber-faced squeegee at a rate of 1 gallon of the diluted seal coat to 100 square feet of surface.

After the first coat has dried, the material for the second coat should be stirred until it is homogeneous in color and consistency. The second coat does not normally need to be diluted. This coat should be applied at right angles to the first coat. It should be poured on the surface in parallel lines and spread with a squeegee, pulling the material slightly toward the body to obtain a smooth uniform finish without ridges. The second coat will usually cover 50 to 75 square feet per gallon. The surface should dry for 8 to 24 hours before being opened up to traffic.

5. JOINT-AND-CRACK SEALERS

Joint-and-crack sealers are products formulated to seal both expansion and contraction joints and any cracks. They should not be considered the same as surface sealers because they are not formulated for that use. When used for Portland-cement concrete pavements, they should be used in joints only, unless the manufacturer of the product specifically states otherwise.

Joints and cracks 3/8-inch or wider should be examined to see if the joint or crack opening extends completely through the pavement. If it does, it should be filled, but not compacted, with oakum or dry fine sand up to approximately 1-1/2 inches below the level of the pavement surface prior to application of the bituminous filler.

Bulk joint-sealing material should be transferred from the container into a spout or conical pouring can, and then poured into the opening. The sealant should be used sparingly, pouring only sufficient material to fill the opening flush with the surface. Overfilling produces objectionable buildup, causing bumps. All material above the surface should be removed or wiped off with a squeegee. Where the pavement surface is sloping in the direction of the joints or cracks, dams should be made with small pieces of cardboard. These are cut a little wider than the openings, bent vertically and placed in the opening, and straightened to hold them in place. Space them to prevent the sealing compound from flowing out of place before it has set. Where material overflows the joint or crack, the excess should be smoothed or wiped off with a trowel or squeegee (see Figure 3-3).

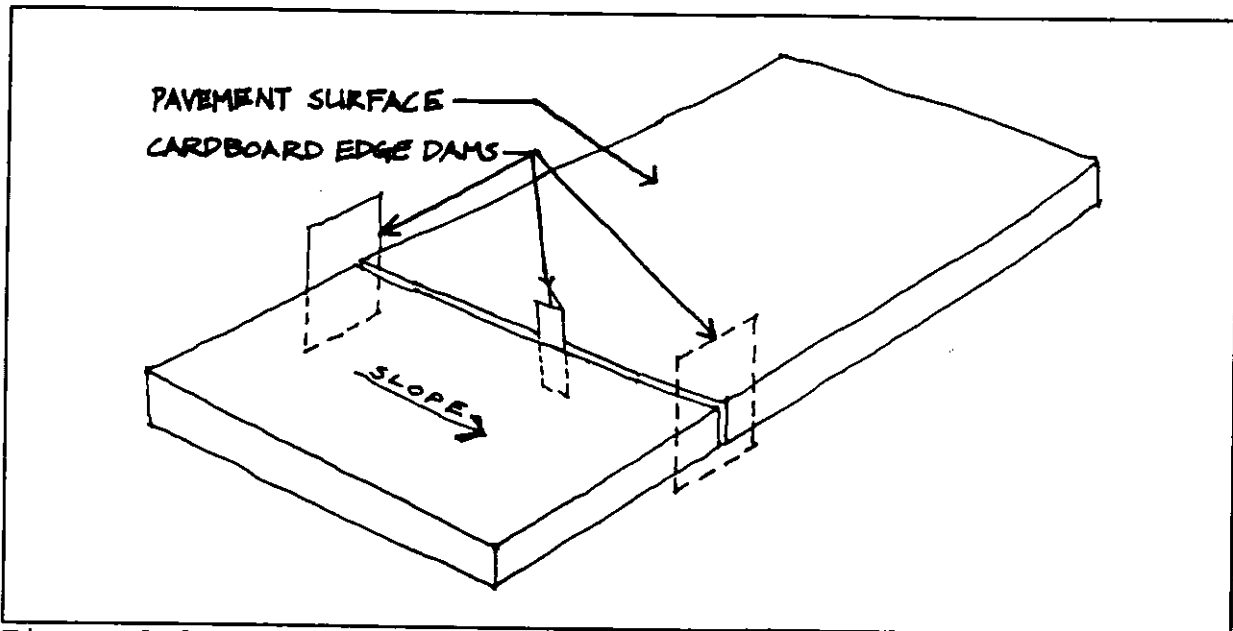


Figure 3-3: Sealing Sloping Surfaces

Immediately after filling the joint or crack and squeegeeing excess material off the surface, sprinkle fine sand over the area to prevent tracking by pedestrian or vehicular traffic.

6. PREPACKAGED OR PREMIXED PATCHING MIX

Prepackaged or premixed patching materials are very good for making emergency repairs. Emergency or temporary repairs should be made in accordance with the directions on the package. First, thoroughly clean, then fill the hole with the prepackaged mix to a level approximately one-half inch

above the surrounding surfaces. After thorough tamping to the level of the adjacent pavement surface, it is ready for traffic.

Permanent repairs and patches using pre-mixed or pre-packaged materials should be made in the following manner. The hole should be prepared, cleaned, and primed. The primer should be compatible with both the existing pavement material and the prepackaged or premixed patching mix. While the prime coat is still tacky, the patching mix should be shoveled, *not* dumped or dropped in place. Dumping or dropping would necessitate turning or moving the material to get a uniform texture. The patch mix should be leveled and spread with rakes, shovels, or lutes to get uniform placement.

Further, it should be placed and compacted in layers not exceeding two inches in depth. Then compacting should be done with hand or air tampers or rolled until the top layer is smooth and even with the adjacent surfaces. A straight edge or taut string may be used as a guide. (It is much better to have the patch slightly above the surrounding surfaces than below them.) After the patch has been allowed to set 8 to 24 hours, a sealer should be applied. When the sealer is dry, the pavement can be opened to traffic.

SECTION C RECOMMENDED REPAIRS TO CORRECT DEFICIENCIES

1. SHRINKAGE AND LOCALIZED CRACKING

a. Description of Deficiency

Shrinkage, checking, or cracking occurs in various shapes. These conditions may be found even on a comparatively new paving surface. The checking or cracking will first appear in the form of fine hairline cracks which are most prominent when wet. If immediate corrective action is not taken, the size of cracks increases. This condition can be caused by any or all of the following:

- Bitumen layer not thick enough;
- Overheating of bitumen (when mixed in the plant);
- Age of pavement;
- Moisture-sensitive aggregate in the mix;
- Brittleness due to insufficient use or defective bitumen in the mix.

The various cracking patterns (see Figure 3-4) include the following:

- **Hairline cracks:** caused by asphalt shrinkage or hardening, lack of compaction during construction.
- **Block cracks:** cracks that divide the pavement into rectangles caused by asphalt shrinkage or hardening.

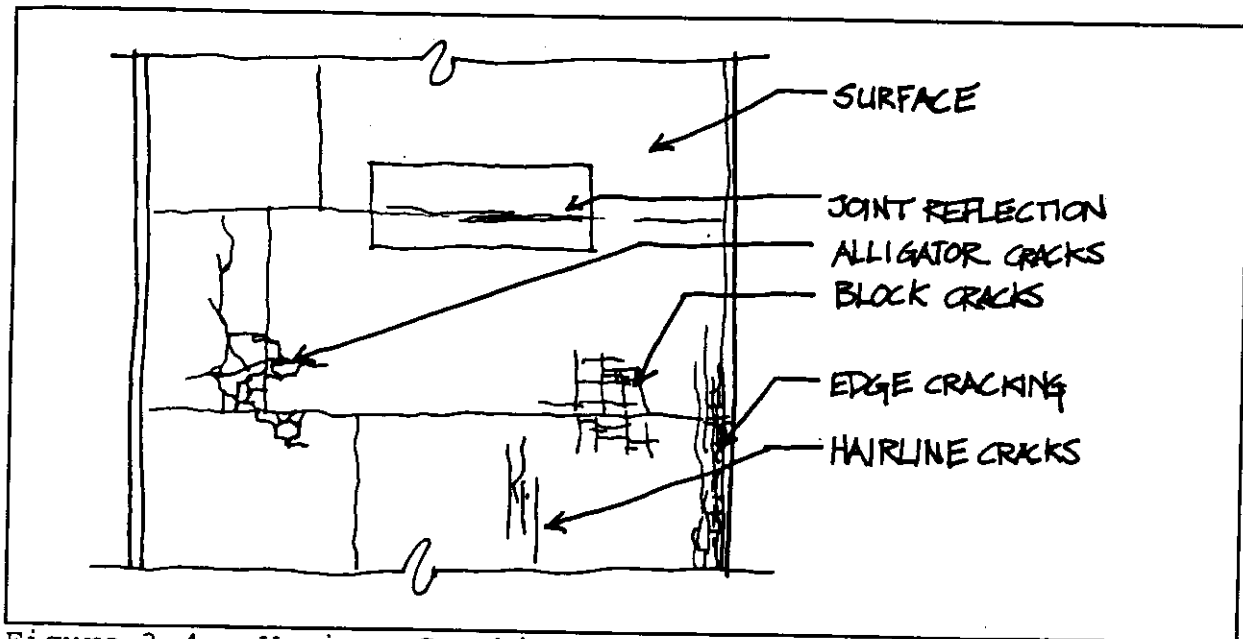


Figure 3-4: Various Cracking Patterns

- **Alligator cracks:** polygon-shaped cracks connected together, caused by repeated loads on a weak base and/or subbase, or movement of the subbase.
- **Edge cracking:** cracks close to the outer edge of the pavement caused by a weak base or subbase or a thin pavement section.
- **Joint reflection:** cracks in an overlay at the joints of concrete pavement.
- **Slippage cracks:** cracks that exist in the shape of half-moons and point away from the direction of traffic and are caused by loss of bond between pavement lifts, resulting from dust or dirt on pavement at time of paving, and heavy vehicles braking or turning.

b. Materials, Equipment, and Personnel Required

Listed below are the materials, equipment, and personnel necessary to repair crack defects.

- **Materials Required:**
 - Hairline cracks - Easy-flow emulsion seal coats or sealers;
 - Block and alligator cracks - Coal-tar pitch emulsion or synthetic-rubber modified or asphalt-emulsion seal coat or sealer, or heavy-duty emulsion mixes;
 - Edge cracks - Prepackaged mix.
- **Equipment Required:**
 - Dump truck;
 - Air compressor;
 - Pour pots;
 - Street brooms, hand shovels, pick, hand tamp;

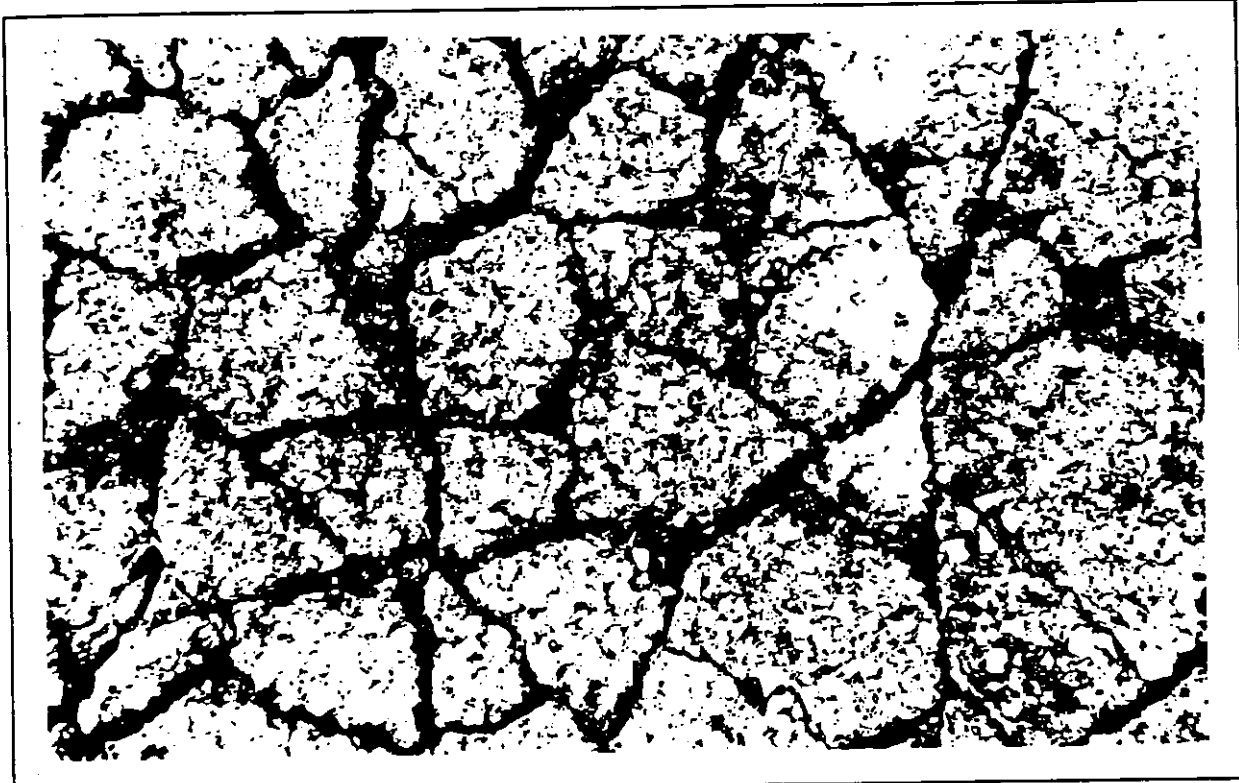


Figure 3-5: Alligator Cracking

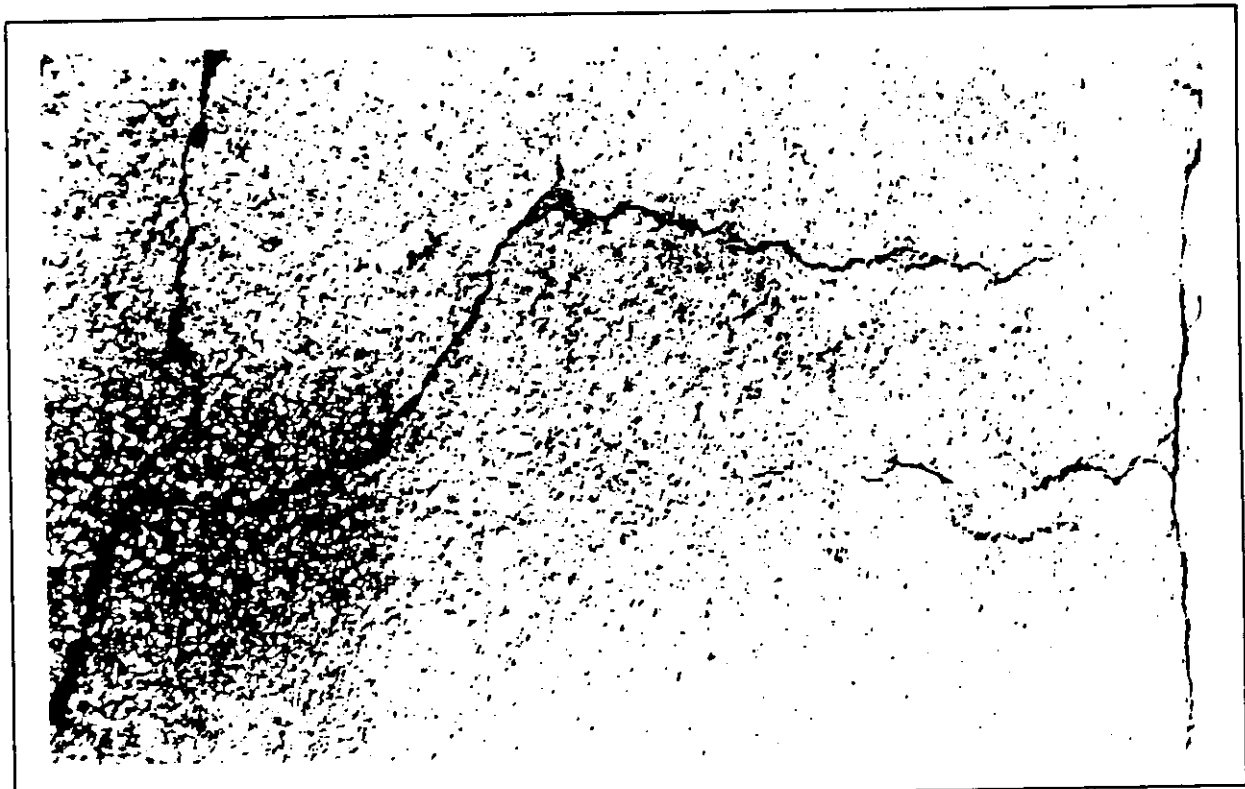


Figure 3-6: Edge Cracking

- Traffic signs and devices (cones, flags, etc.).
- Personnel Required:
 - Supervisor, if available and needed;
 - Laborers
 - Flaggers, if necessary.

c. Recommended Repair Procedure

The following procedures are applicable to the previously discussed cracking patterns:

- Set up signs for maintaining traffic as needed. Refer to the Manual for Uniform Traffic Control Devices (MUTCD).
- Flag traffic, if required.
- Broom and blow off area to be patched to remove loose materials.
- Blow out cracks; if existing surface comes loose, use prepackaged patch material.
- Tamp prepackaged mix.
- Seal cracks and lightly scatter sand over fresh oil to prevent tracking by traffic.
- Clean up any loose sand.
- Move to next patch.
- Repeat work method.

Methods for correcting these defects depend upon the amount and size of cracks, the degree of surface fatigue, and whether complete pavement failure has occurred.

Method 1: Where there are hairline or small cracks not over one-eighth inch, or very slight settlements. Correct hairline cracks as described in Section B, Part 2: Easy-Flow Emulsion-Type Seal Coats or Sealers.

Method 2: When the surface shows greater signs of distress, such as open cracks or deep pitting, but the base and subbase are stable. The distressed condition may be corrected by removing all dirt and loose particles from the cracks, cleaning the surface, and applying one of the following:

- A heavy-bodied emulsion seal coat or sealer;
- A coal-tar pitch emulsion;
- A synthetic-rubber modified tar;
- An asphalt-emulsion sealer or seal coat.

Allow patch to cure before opening to traffic.

2. LONGITUDINAL AND TRANSVERSE CRACKING

a. Description of Deficiency

Longitudinal cracks run parallel to the length of pavement and transverse cracks run perpendicular to the length of pavement (See Figure 3-7). These cracks are caused by:

- Underlying concrete joints reflecting through a bituminous overlay;
- Contraction or movement in the base or subbase;
- Shrinkage or swelling of the subbase soils.

b. Materials, Equipment, and Personnel Required

- **Materials Required:**
 - Joint sealing compound;
 - Sand to cover fresh bitumen and prevent tracking by traffic.
- **Equipment Required:**
 - Dump truck;
 - Bitumen heater;
 - Pour pot;
 - Air compressor with extra hose and fitting to blow out joints (usually 4 or 5 feet of pipe with one end hammered to a narrow rectangular opening and the other end adapted to clamp to the compressor hose);
 - Street broom, hook for removing dead sealant in cracks;
 - Hand shovel for transporting small amounts of bitumen;
 - Signs and traffic devices.
- **Personnel required:**
 - Supervisor, if available;
 - 4 laborers (more if flagging traffic is needed);
 - Truck driver, if available and needed.

c. Recommended Repair Procedure

Sealing cracks and joints prevents seepage of water into the subbase, which causes its instability. Sealing the cracks also prevents dirt from plugging the joint, which in turn allows the pavement to expand.

This operation is best done during warm, dry weather. Set up required signs and traffic devices, if necessary. The method of sealing varies with the size of the opening involved. First, the cracks

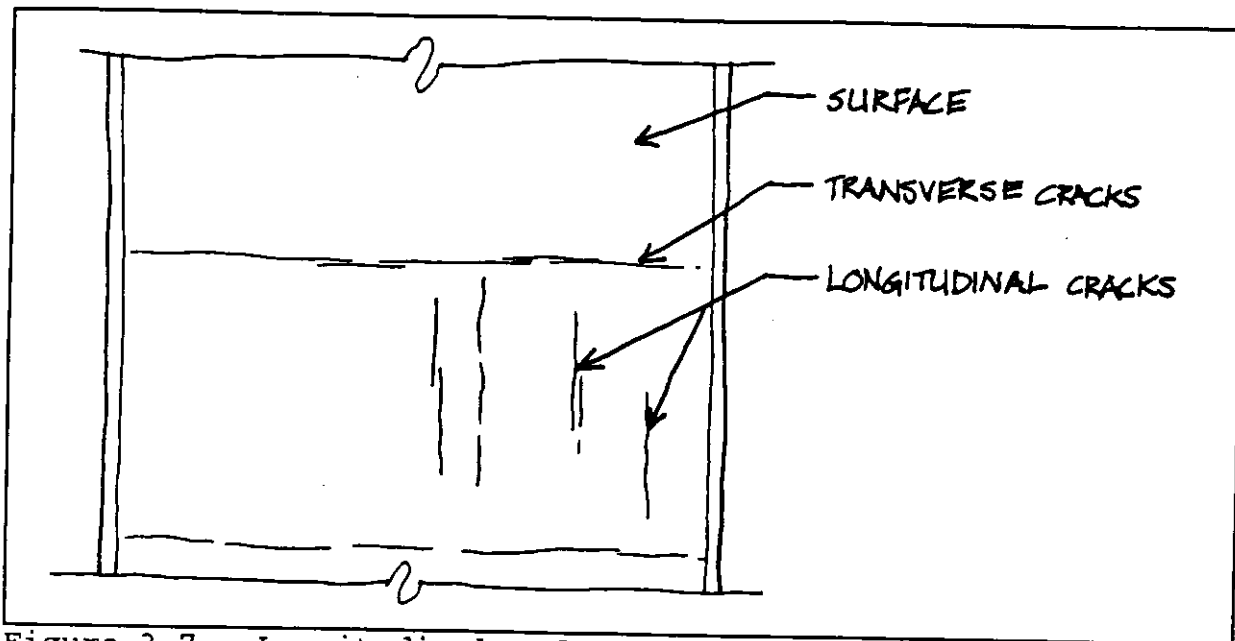


Figure 3-7: Longitudinal and Transverse Cracks

or joints should be thoroughly cleaned of all dust, dirt, dead sealing material, broken rock, or gravel by using a broom, brush, or air compressor. Embedded rock, gravel, or dead sealing material can be removed with a hook or screwdriver. The sides of the crack or joint should be dry before a sealer is applied. A blow torch should be used, if necessary, but care should be taken not to burn the existing bitumen in the crack or joint.

3. RAVELLING .

a. Description of Deficiency

Ravelling and abrasion of the surface is caused when the loss of fine surface materials roughens the surface pavement. Pitting, as the word implies, consists of small depressions where individual particles of embedded aggregate have popped out. There are two basic causes for these conditions:

- Wear and tear by traffic;
- Inherent faults of the paving mixture such as too little bitumen, burning of bitumen, or disintegration of the aggregate resulting from excessive temperatures during plant drying and mixing processes.

b. Materials and Equipment Required

- Material Required:
 - Easy-flow emulsion sealer.

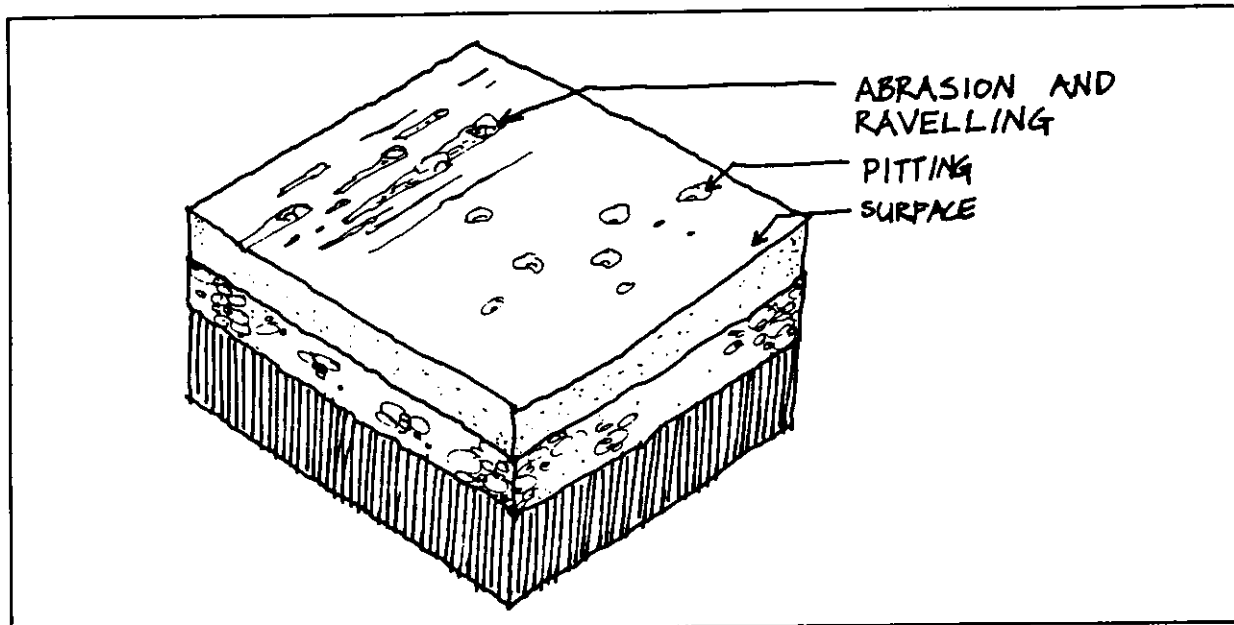


Figure 3-8: Raveling, Abrasion, and Pitting

- Equipment Required (for small areas):
 - Dump truck;
 - Squeegees;
 - Signs and cones;
 - Hand shovels (square point), brooms.

c. Recommended Repair Procedure

To correct this condition, provided that the raveling, abrasion, or pitting has not progressed too far, apply a coat of easy-flow emulsion seal coat or sealer. This will hold the surface particles in place and prevent further raveling. If the raveling, abrasion, or pitting is pronounced or well advanced, apply a heavy-bodied emulsion seal coat or sealer.

An application of a coal-tar pitch emulsion or synthetic-rubber modified-tar or asphalt emulsion seal coat or sealer may also be used to correct this condition. For large areas, a light coat of an RC or MC oil should be applied with an asphalt distributor. Consult a local supplier for the type and application rate. For areas that have become seriously pitted, a single or double surface treatment or a bituminous overlay should be done.

Do not allow traffic to use the repaired area until it has been thoroughly cured, because traffic will strip it off and track it onto the adjacent areas.

4. RUTTING

a. Description of Deficiency

This type of distress causes the pavement surface to become rough, warped, uneven, and depressed in the wheel paths. It may also crack in various patterns. It creates a hazard for both foot and vehicular traffic. Water accumulates in the depressed areas and penetrates into the foundation, which makes conditions worse.

Distortion and settlement are usually due to foundation weaknesses, such as poor compaction of the subbase or a soft spongy subbase caused by water penetration, in combination with repeated stopping and starting of vehicles. The methods of repair depend upon the extent of damage.

b. Materials and Equipment Required

For small areas with minor rutting, prepackaged mix or premixed patch material is required, as well as emulsion for sealing cracks.

c. Recommended Repair Procedures

Where cracking is not extensive and the depression or settlement is not over one-half inch, the repair can be made by applying a skin patch or slurry. The slurry material is made by adding fine mineral aggregate, such as graded sand or heavy-bodied emulsion sealer, coal-tar pitch emulsion, synthetic-rubber modified-tar, or asphalt-emulsion sealer. The fine aggregate should be clean, well-graded sand passing a number-16 sieve, and should usually be proportioned at four pounds of fine aggregate to one gallon of sealer, unless otherwise specified on the label of the emulsion container. This is generally referred to as "slurry." The slurry is applied in the same manner as heavy-bodied sealer. An alternate material is a prepackaged or hot-mixed bituminous concrete.

The depressed area may be leveled to marked lines or with a straight edge to create a smooth surface. If hot mix is used, the ruts should be adequately "tacked," and the area to be "feathered-in" should also be tacked for about 6 inches beyond the feathering. Too much tack can be detrimental, causing the new patch to move.

5. SHOVING

a. Description of Deficiency

This problem is very similar to rutting in appearance, occurring in places where there is frequent braking and stopping, such as at a stop sign, or turning of heavily loaded vehicles. There is no failure in the base or subbase; the surface is displaced or shoved to the side without break up.

b. Materials, Equipment, and Personnel Required

- **Materials Required:**
 - Hot mix bituminous or prepackaged mix;
 - Tack coat.
- **Equipment Required (for small areas and minor shoving):**
 - Dump truck;
 - Traffic signs and cones;
 - Hand shovels, lute, asphalt rakes, brush for applying tack coat;
 - Hand brooms.
- **Personnel Required:**
 - Supervisor, if available and needed;
 - Laborers;
 - Truck Driver, if available and needed.

c. Recommended Repair Procedures

For minor repairs, the most practical solution is to fill the ruts with hot mix so they are brought up to the original level of the pavement.

- Set up traffic signs and cones, as applicable.
- Assign flagmen, if necessary to control traffic around repair area.
- Mark off area to be filled, and tack coat.
- Fill with hot mix.
- Allow hot mix to cool to prevent pick-up or shoving of new repair.
- Clean up site and take down signs.

For major repairs, the "shoved" surface must be milled or planed to the original surface level. It is likely that the hot mix will have to be placed in the wheel tracks to get a proper repair. Since the equipment required for this is probably not available to the HA, it may have to be done by contract.

An alternate method, if the equipment and skilled operator are available, is to plane the area with a grader. The area to be planed should first be heated to allow the grader to cut the surface to be removed. This is a slow process and is not recommended unless the shaved area is limited in size.

6. EDGE FAILURE

a. Description of Deficiency

This type of failure appears along the edges of a pavement not protected by curb, walk, or edging strip. As cracks appear, the surface begins to ravel, and both surface and foundation of the pavement begin to disintegrate (see Figure 3-9). The failure may be caused by poor construction, saturated subbase, insufficient thickness of surface material, and excessive loads. Subbase saturation is caused by water seeping through surface cracks or water standing because of blocked drains or low areas.

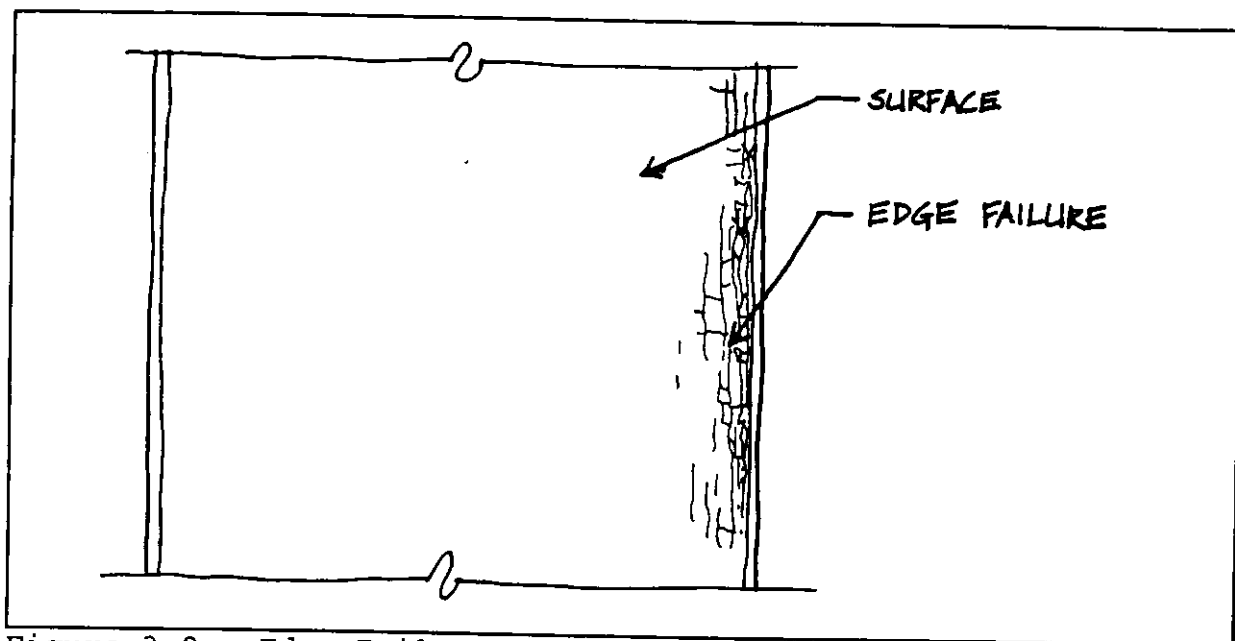


Figure 3-9: Edge Failure

Edge failure requires immediate action. It is one of the deficiencies which develop rapidly into complete failure requiring complete reconstruction. With the various causes of this type of failure, the following steps are suggested as soon as the first cracks appear:

- Check the drainage. If poor drainage is the cause of foundation failure, provide adequate drainage. In some instances, the installation of a concrete or brick inlet may alleviate the problem. The type and size of inlet and pipe to carry the water to a ditch, another pipe, or

wherever the water is to be discharged should satisfy the applicable requirements of the local jurisdiction. In some cases, it is advisable to engage the services of a professional engineer.

- Apply a seal coat. If the foundation is stable, the crack along the edge of pavement can be corrected by applying a heavy-bodied emulsion seal coat or sealer or a synthetic-rubber modified-tar or asphalt-emulsion seal coat or sealer.

If the edge failure has progressed to a condition where the surface has disintegrated and there is insufficient base thickness or unstable subbase, it will be necessary to remove the defective surface, base, and unstable material of the subbase and to replace them with suitable materials. The methods for this are basically the same as those described in Chapter Two for making a full-depth permanent patch.

b. Materials, Equipment, and Personnel Required

- **Materials Required:**
 - Subbase;
 - Seal coat compound or prepackaged mix or hot mix asphalt;
 - Tack coat.
- **Equipment Required:**
 - Back hoe;
 - Trucks for hauling away excavation and base, if used;
 - Truck for hauling patch material;
 - Hand shovels, asphalt rake, lute, brush for tack coat, street broom;
 - Traffic signs and cones.
- **Personnel Required (as needed and available):**
 - Supervisor;
 - Laborers;
 - Operator;
 - Truck drivers.

c. Recommended Repair Procedures

- Put up signs and traffic devices (cones, etc.).
- Dispatch trucks to pick up aggregate, if used.
- Excavate failed area.
- Square up hole.
- Refill subbase and base with new materials.
- Tack sides of hole.

- Repatch paved area.
- Clean up area.
- Take down signs.

7. PAVEMENT FAILURE/POTHOLES

a. Description of Deficiency

Potholes or pavement failures (see Figure 3-10) are among the most dangerous failures, and require immediate attention. Potholes start with a shallow surface failure which rapidly wears away, exposing the base and subbase and permitting water to gather and traffic to break down the bond, resulting in holes which look like pots.

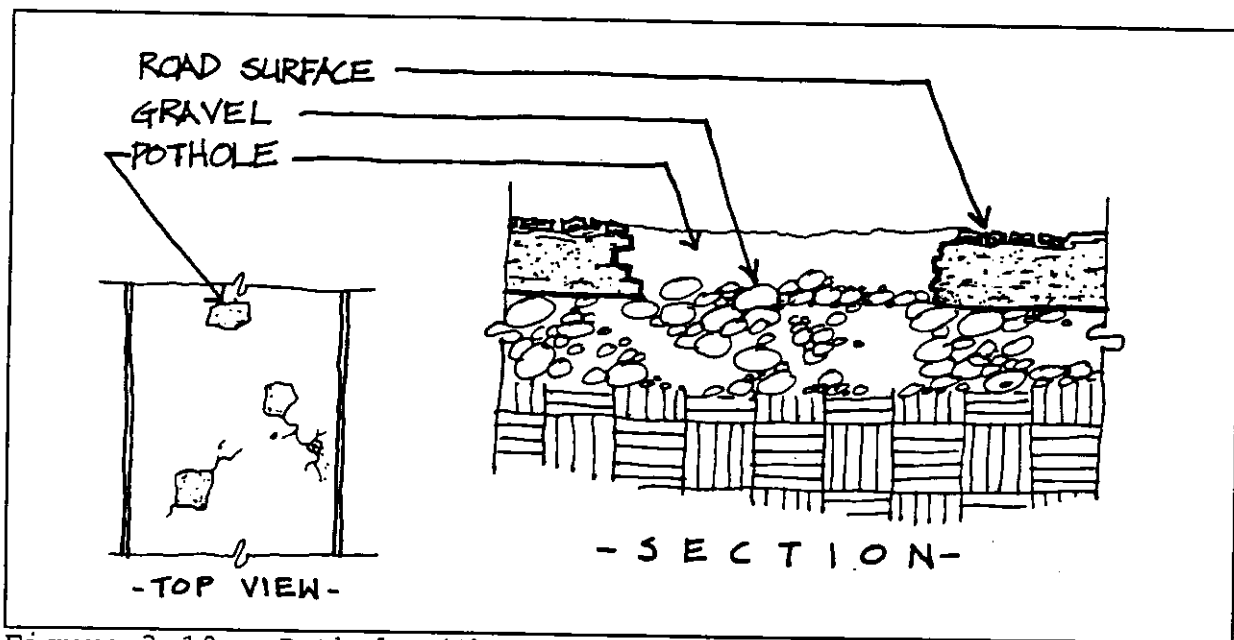


Figure 3-10: Potholes/Chuckholes

Potholes are generally caused by structural weakness or poor drainage, which, especially in the cold season, may result in complete localized failure of the road structure. Potholes or chuckholes continue to grow in size until repaired by patching; therefore, they should be repaired as soon as possible.

Potholes or chuckholes usually develop at the most unseasonable time of the year, when a permanent repair cannot be made effectively and emergency repairs should be considered. Cold premixed or prepackaged material should be used for a temporary patch. The repairs should be

checked frequently, depending on weather conditions, the amount of traffic, and the location of the pothole.

Pavements may also fail because of structural deficiencies such as:

- Surface deterioration due to weathering, cracking, raveling, or spalling;
- Failure caused by inadequate material strength, insufficient thickness of the base, cracking due to expansion, contraction, or movement of the subbase.
- Subbase weakness due to unstable, wet, or soft materials, or poor compaction.

Surface deterioration and delay in taking corrective action will cause a chain reaction whereby the surface, base, and subbase will fail completely or in part. Such a failure will require the removal of all defective materials and their replacement with a patch of sound and durable materials properly bonded to the surrounding area. See Chapter One for the sequence of steps required in making a good permanent patch.

b. Materials, Equipment, and Personnel Required

- **Materials Required:**
Several materials are now available for use in making emergency repairs regardless of weather conditions (except freezing). It is necessary only to sweep out all excess water and loose materials and fill the hole with emergency repair materials, which are to be compressed or tamped in place with a tamper or shovel, then open for traffic.
- **Equipment Required:**
 - Truck;
 - Hand tamp;
 - Flags for flagging traffic.
- **Personnel Required:**
 - Laborers.

c. Recommended Repair Procedures

Determine whether poor drainage is a factor contributing to the failure. If it is, provisions should be made to get rid of the water and make a patch. For a permanent patch refer to Chapter Two.

8. PONDING/POOR DRAINAGE

a. Description of Deficiency

The greatest single enemy of any pavement is a saturated subbase or foundation caused by lack of proper drainage. It is a common occurrence, usually caused by buildup of soil on shoulders and adjacent areas which prevents water from draining from the paved surface and causes ponding. The ponded water seeps into the subbase along the edge of pavement, and gradually softens it, resulting in cracking and eventual settlement of the pavement affected by wheel loads. Water can also penetrate horizontally under the pavement and cause potholes.

One of the possible solutions to this problem is to regrade the adjacent area so that it slopes away from the edge of the pavement. The slope should be a minimum of 1/2" to 3/4" per foot where possible. The corrective work should be scheduled in the summer or fall.

b. Materials, Equipment, and Personnel Required

- Materials Required:
 - Grass seed;
 - Straw for mulch;
 - Lime and fertilizer as needed.
- Equipment Required (for small areas):
 - Dump truck;
 - Hand shovels;
 - Mattocks;
 - Picks, rakes, street brooms;
 - Construction and traffic signs.
- Equipment Required (for large areas):
 - Dump truck;
 - Hand shovels;
 - Mattocks;
 - Picks, rakes, street brooms;
 - Construction and traffic signs;
 - Excavator or motor grader (a rubber-tired loader is required to load trucks if a motor grader is used);
 - Dump trucks;
 - Mechanical brooms.

- Personnel Required:
 - Supervisor, if available and needed;
 - Laborers;
 - Truck driver, if available and needed;
 - Operators, as needed.

c. Recommended Repair Procedures

- Set out signs.
- Remove mail boxes or signs which will be in the way of grading (not required on small areas).
- Regrade built-up areas to meet pavement surface. Slope away from pavement at 1/2" to 3/4" per foot.
- Haul away excess material to a designated dump area.
- Re-seed and mulch where necessary.
- Clean up area.
- Take down signs.

Another solution to poor pavement drainage is to install a series of gravel- or stone-filled trenches in sump areas to carry the water from the edge of the pavement to an adjacent ditch. These trenches should be installed so that their bottoms are below the bottom of the pavement base. To get a good slope, it may be necessary to install them in a diagonal pattern through the shoulder to a ditch at a lower elevation. Ditches should be at least one foot wide. The stone or gravel should be well-graded with the maximum size passing a one-inch screen. A two-inch minimum cover of shoulder material for the top of drains should be provided.

- Personnel Required (for small areas):
 - Supervisor, if needed and available;
 - Laborers.
- Personnel Required (for large areas):
 - Supervisor, if needed and available;
 - Laborers;
 - Truck drivers;
 - Operators.

Note: In some cases, the construction of a swale or another drain structure, such as an inlet or drain pipes, are effective solutions to the problem.

Drainage Ditches and Swales: Base failures are also caused by poor maintenance of drainage ditches, which causes water to back up or drain slowly. High water in ditches prevents the subbase from draining, and allows the water from the ditch to penetrate the subbase. The solution to this problem is to clean out any debris, leaves, and silt so that the water can move

freely in the ditch. It may be necessary to establish a steeper grade and/or to increase the size of ditch for moving more water.

The resources (personnel and equipment) needed to solve this problem are the same as for the shoulder build-up problem. Seeding or other types of vegetative covers, if applicable, should be put down as soon as possible after any grading is done to prevent erosion.

END OF CHAPTER THREE

MAINTENANCE GUIDEBOOK III - PAVEMENT MAINTENANCE

CHAPTER FOUR - CONCRETE PAVEMENTS

SECTION A CONCRETE PAVEMENT CONSTRUCTION TYPES

1. CONSTRUCTION TYPES

Concrete pavements are used for roads, driveways, walks, parking, recreation areas, and swales. Figure 4-1 is a section through a concrete roadway, curb, and sidewalk, showing their construction.

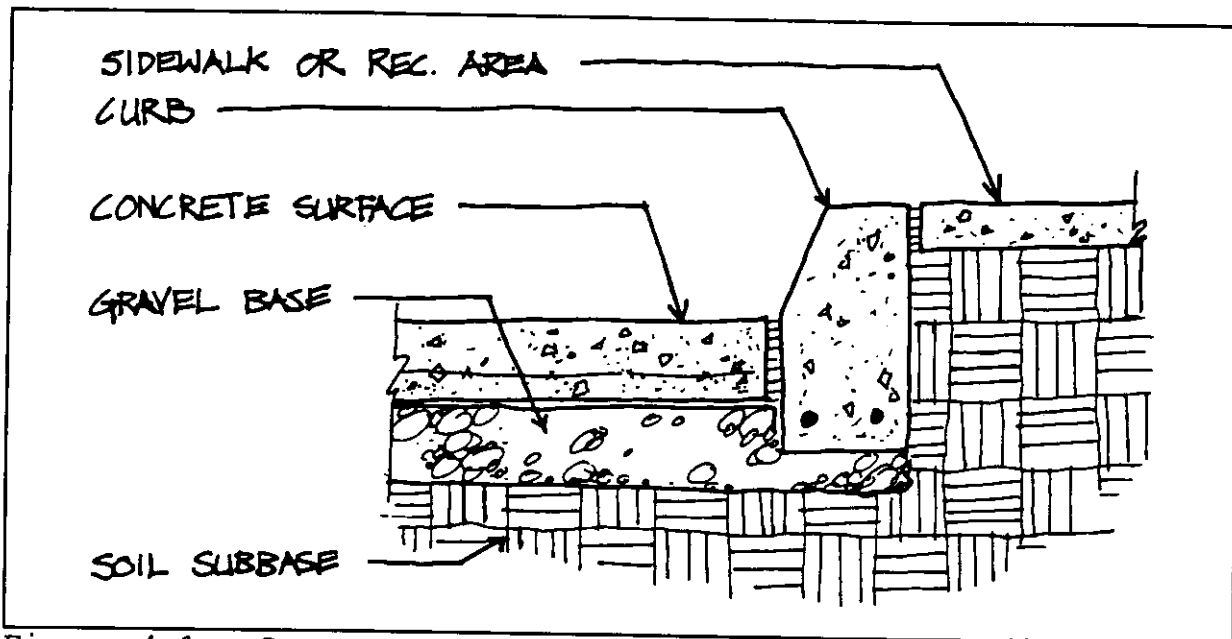


Figure 4-1: Concrete Pavement Construction Types

2. TYPES AND CAUSES OF FAILURES/DEFECTS

Well-constructed concrete pavement requires little maintenance; however, maintenance should not be neglected. Repairing defective areas as soon as practicable ensures the pavement's structural integrity and extends its life. Typical failures in concrete pavement include:

- Longitudinal and Transverse Expansion-Joint Failure: Failure in or directly adjacent to pavement joints.
- Spalling: The breaking, chipping, or fragmentation of the surface of a concrete slab, usually found near joints. The spalling is caused by defective joint construction or by damage due to undesirable and incompressible materials getting into an inadequately sealed joint.
- Scaling: A deficiency which occurs when the surface of a hardened concrete slab breaks away, usually early in the life of the slab. It can be caused by cycles of freezing and thawing.

applications of salts, or overworking the concrete during finishing.

- **Crazing and Map Cracking:** The occurrence of numerous fine hairline cracks in the surface of a newly hardened slab due to shrinkage, resulting from surface drying, premature floating, and troweling and/or overuse of tamper, vibrating screed, darby, or bull float.
- **Failed/Disintegrated Areas:** Pavement areas which are severely deteriorated and present a hazard.

Lack of adequate drainage causes most of these failures and problems similar to those discussed in the Chapter Three - Bituminous Pavement. Where drainage problems appear, the cause should be determined and corrective action taken as soon as possible. Simple drainage problems may be corrected as described in Chapter Three, Section C, Part 8.

SECTION B PAVEMENT MATERIALS

1. CONCRETE MIX TYPES

Concrete is a mixture of any type of Portland cement, sand, gravel or stone, and water. For general purposes, a 1-2-4 mix is used; that is, one part Portland cement, two parts sand, four parts gravel or stone. Four to six gallons of water per sack of cement should be added, depending on the amount of moisture in the sand, gravel, and stone. These proportions may vary, depending upon the size of the aggregate used and the desired strength of concrete (less water results in higher concrete strength). For concrete less than two inches thick, the size of gravel or stone should not exceed 3/8-inch. For concrete over two inches thick, the maximum size of gravel or stone should be 3/4-inch. The concrete should be made fairly stiff, but workable. It should never be sloppy.

a. Plant Mix

When a transit-mix plant is nearby, the concrete may be purchased and delivered to the job, ready-mixed and ready to be placed. The strength of concrete depends on local code requirements for sidewalk or pavement repairs; generally, 2500- to 3000-psi.

b. Prepackaged Concrete Dry Mix

Dry-mix concrete may be purchased in prepackaged form, in which cement and gravel are proportioned and premixed at the factory. The mix should be emptied on a board or in a wheelbarrow, and thoroughly mixed with water. The amount of water to be added is about one gallon per 90-pound bag of concrete mix. Too much water will decrease the strength of concrete.

c. Portland Cement

Portland cement is a general-purpose cement suitable for most uses except when specialized types of concrete are required. It develops its design strength in 28 days, when properly cured at a temperature of 70°F.

For the repairs described in this guidebook, concrete or mortar finishes may be opened to foot traffic after 48 hours, and after 7 days to vehicular traffic, provided that the temperature does not fall below 70°F, and the surface is properly cured and protected.

d. High Early-Strength Portland Cement

High-early strength Portland cement is a true Portland cement with additional accelerating agents. It is used where high strengths are required at a very early stage—one to three days after placing it. It develops its design strength in 24 hours. It is used where quick results are required, since it may be opened to both foot and vehicular traffic after 24 hours, provided that the temperature averages 70°F.

e. Air-Entrained Portland Cement

Air-entrained Portland cement, in which air-entraining materials are mixed, was developed to produce a concrete which is resistant to severe frost and to the adverse effects of salt used to melt snow and ice from the pavement. Concrete or cement-sand mixes made with this type of cement require less mixing water than nonair-entrained cements, but have the same slump, and permit finishing procedures sooner than a nonair-entrained Portland cement. Air-entrained Portland cement, either standard or high early-strength, can be purchased from local material suppliers, some lumber yards, and hardware stores, in 94-pound bags.

f. Cement-Sand Mix Finish or Topping

Cement-sand mix finish or topping is a combination of any of the above Portland cements and graded sand. The proportions, for general use, are one part Portland cement to two parts well-graded sand.

g. Prepackaged Dry Cement-Sand Mix

Prepackaged dry cement-sand mixes are available in 80-pound bags. The mix contains one part Portland cement to two parts sand. One sack of the prepackaged mix requires approximately one

gallon of water and covers approximately eight square feet, one-inch thick. Other prepackaged mixes are also available. The supplier should be consulted to determine the mix most suited to the HA's needs.

h. Epoxy-Resin Bonding Agents or Adhesives

Epoxy-resin bonding agents or adhesives are used for bonding new concrete to existing concrete. There are many "epoxy-resin" compounds available, formulated for particular uses. It is necessary, therefore, to select an epoxy specially formulated for the purpose of bonding of cement or concrete applications.

Before applying, read carefully the instructions on the containers. *Follow all directions.* Epoxy bonding agents have a short pot-life and usually set in one to two hours, depending on the temperature. Therefore, no more should be mixed than can be used in the time specified by the manufacturer.

i. Acid Etching and Cement Wash

This is probably the oldest method of bonding fresh cement-sand mortar or concrete to existing concrete. The existing concrete to be resurfaced should be cleaned and all loose and undesirable materials removed. A dilute solution containing one part commercial muriatic acid to nine parts of clean water should be made (the acid should always be poured into the water; never the water into the acid). This solution should be thoroughly brushed or broomed on the area to be resurfaced. After about 15 minutes, the surface should be flushed with water until all of the acid solution has been removed. Then, a thin layer of dry cement-sand-mix (approximately 1/8-inch thick) should be sprinkled over the wet concrete surface and uniformly broomed into the surface, displacing all air.

j. Latex Concrete Patch Materials

Latex concrete is a general-purpose product, formulated primarily for use in areas requiring thin overlays or patches such as concrete walks, floors, or other slabs. It may be applied from 1/2-inch thick to featheredge. This material has a drying time of approximately one hour. Mix only as much as will be used within the hour.

Latex concrete patch materials consist of latex (liquid binder) and powder (dry, premixed cement and fine aggregates). These two components may be secured in one package containing the powdered ingredients and a specially formulated latex. If desired, the latex may be purchased

separately and mixed with Portland cement and sand, in a proportion of 1:2-1/2.

The surface should be protected from traffic until the mixture is dry. Drying time, under normal conditions (70° to 80°F temperature), will be approximately 1 to 2 hours for thicknesses up to 1/4-inch. Longer setting time is required for greater thicknesses. Liquid latex should not be applied when the temperature is below, or is anticipated to go below, 50°F and the repaired surfaces should be protected against freezing.

k. Acrylic, Epoxy, and Polyurethane Coatings

These coatings have been developed in the past few years to provide protective coatings for assorted concrete surfaces. They are bright, wear well, and are easy to repair. They are applied like paint with brush, roller, or sprayer. Since these materials are coatings, the surface to receive them must be sound, smooth, clean, and free of all loose materials, dirt, and oil. Read the directions on the label before opening the container.

It is recommended that the material be applied in two coats. The first coat is usually thinned as designated on the container label. The thinned material may be spread evenly over the surface with a long-handled push broom roller or a 5-inch wide brush. The coverage will vary from 100 to 150 square feet per gallon, depending upon the porosity and roughness of the surface. After the first coat has dried, the second coat should be applied directly from the container in the same manner. The coverage will be approximately 150 square feet per gallon. The coating should be thoroughly dry before the area is opened to traffic.

These coatings should not be applied on a wet surface, nor when the temperature is below 50°F. All equipment should be cleaned immediately after use.

SECTION C WEATHER CONSIDERATIONS

1. COLD-WEATHER CONCRETING

In winter, the following precautions should be taken to protect new concrete:

- Do not place concrete on a frozen subbase. There is a chance that the frozen subbase will undergo considerable settling when it thaws.
- Do not place concrete in or against icy forms. Remove ice from the inside of forms and from the reinforcing steel.
- Do not try to place concrete without enough qualified personnel. It is very important to place and finish concrete as rapidly as possible.

- To prevent surface damage, delay final finishing of flat surfaces until concrete is between 50° and 70°F, and all surface water has disappeared.
- Protect the surface of the concrete slab from direct exposure to rain and sleet because any water-saturated concrete less than a month old is susceptible to damage from freezing. This may be done by placing burlap or plastic on the surface as soon as possible after finishing.
- Concrete mixes with air-entrainment are recommended for patching concrete paving and surfaces wherever severe frost action occurs, or where it is anticipated that repeated application of deicers such as calcium chloride, sodium chloride, or other similar salts will be used. Air-entrained concrete or air-entrained cement for concrete may be obtained from any transit-mix concrete company or a material supplier.
- The use of calcium chloride is not recommended. It is a salt which can damage the concrete.

2. HOT WEATHER CONCRETING

Difficulties may also arise when placing concrete in hot weather. Rapid drying of a flat concrete surface will result in cracks and a loss of concrete strength. Because of rapid setting of the cement and excessive absorption and evaporation of mixing water, the concrete may stiffen before it can be consolidated, causing difficulties when finishing. Before proceeding with concrete work in hot weather, compliance with the following precautions will minimize future problems:

- Be prepared with necessary equipment and personnel well in advance of starting work.
- Have ample water supply for sprinkling subbase and forms, and curing the new concrete surface.
- Have burlap mats, polyethylene sheets, and lumber ready to protect the fresh concrete from the effect of direct sun or have a curing compound with application equipment available. All materials should be on the site before the placing of concrete begins.
- Schedule work so that concrete can be placed and finished with the least delay. Starting at 5:00 or 6:00 am, or earlier if possible, is recommended if the repair is large or will require a long time.
- Do not delay in placing concrete.
- Start finishing operations as soon as the surface is free of bled water.
- If possible, use a fine spray to protect the finished surface from drying out too rapidly. Take care, however, not to start the spraying too soon, which could damage the finished surface.

Concrete surfaces should be protected by laying on wet burlap, wet cotton mats, or using a curing compound so that little or no moisture is lost during the early stages of hardening. The burlap and mats should not be allowed to dry out for 7 days (3 days if using high early-strength concrete).

The surface may also be protected by applying a curing compound as soon as the surface is hard enough to resist marring. Although it is more convenient, the use of a curing compound is not as effective as the burlap or mats in very hot weather.

SECTION D FORMING, PLACING, AND FINISHING

1. FORMING

Where required, forms and screeds (leveling boards) should be put in place accurately. The subbase should be properly prepared, shaped, and compacted and sprinkled lightly with water before placing concrete. When concrete is placed on an old concrete surface, the substrate should be clean and properly treated with epoxy bonding adhesive or acid-etched cement wash.

The concrete should be dumped, spread, and thoroughly spaded along the forms, screeds, or surrounding existing concrete edges to eliminate voids or honeycombing. It should be struck off to proper grade, and immediately darbied before any free water has bled to the surface.

Precautions should be taken not to overwork the concrete while it is still plastic, because water and fine material in it can be brought to the surface, which may lead to scaling, crazing, or dusting at a later date.

2. PLACING

The solid materials used in making concrete are heavier than water. Thus, shortly after placement, these materials have a tendency to settle to the bottom, forcing the water to the surface. This reaction is called bleeding. Bleeding usually occurs with nonair-entrained concrete, but not when air-entrained cement is used. It is important that concrete placing and screeding be performed before any bleeding takes place. Any operation performed on the surface while bled water is present will result in scaling, dusting, or crazing. This point cannot be overemphasized, since it is a basic rule for successful finishing of concrete surfaces. The concrete surface is screeded in the same manner as previously described for mortar topping.

When all bled water and sheen has left the surface and the concrete has started to stiffen, except for applying the topping materials, it is time for the other finishing operations, such as edging, grooving, floating, troweling, and brooming.

3. FINISHING

After it has been struck off and screeded, air-entrained concrete is finished in the same fashion as nonair-entrained concrete. All tools should be cleaned after completing concrete work.

SECTION E FINISHES

1. CEMENT-SAND MORTAR TOPPING

Old or existing concrete surfaces which have deteriorated or where a smooth surface is desired can be repaired by mortar topping. The mortar is placed only after the old concrete has been properly prepared to receive it. When topping is to be placed on old concrete, forms should be set where necessary. The existing concrete surface should be cleaned and treated with an epoxy bonding agent or given an acid-etching and cement wash as previously described.

Cement-sand mortar topping is made by adding enough water to a cement-sand mix to make a stiff workable mortar. The mortar should be just wet enough so that all grains of sand are coated with cement paste, without excess water. It should spread easily.

Mortar topping can be placed on fresh concrete for a finished surface; however, this is not necessary if a proper concrete mix is used. Mortar topping should be placed on wet or fresh concrete as soon as possible after the concrete substrate has been struck off and leveled. The topping should be poured on the prepared subsurface and struck off by moving a straightedge back and forth, with a saw-like motion, across the top of the forms or the surrounding surfaces of the slab. A small amount of mortar topping should always be kept ahead of the straightedge to fill in low spots and maintain an even surface. When Portland cement or high early-strength cement is used in the cement-sand mix, there will be a water sheen on the surface after the mortar finish has been spread by the straightedge. This water sheen does not appear when air-entrained cement is used.

As soon as the water sheen has left the surface and the mortar begins to stiffen, an edging tool should be run back and forth along the edge of the concrete, next to the forms. Care should be taken that the shoulder of the edger does not leave a deep impression in the slab. Immediately following edging, the slab should be grooved, where necessary, to match grooves in existing slab, or directly over the existing previously grooved joint. The slab should then be floated with a wood float to an even surface, removing undesirable marks left by the edger and groover.

If a smooth hard finish is desired, the surface should be steel-troweled immediately following the floating. The surface should then be allowed to set until it will support the weight of knee boards without marking or marring the surface. The surface is then given the second or final troweling to improve the texture and produce a smooth, dense, and hard surface.

Smooth surfaces may become slippery and hazardous when wet. A non-skid surface can be obtained after the steel-troweling by lightly brooming the surface by drawing a fine-bristled push broom over the

surface to produce a roughened texture for better traffic under foot. Immediately after completion of finishing operations, the surface should be protected and precautions taken.

When an air-entrained cement mix is used, there is no waiting for surface water to evaporate; therefore, finishing operations should start before the surface becomes dry or tacky. Edging and grooving are done as described above. The use of an aluminum or magnesium float is essential. A wood float drags and increases the work necessary to accomplish the same result.

2. DRY-DUST OR MONOLITHIC FINISH

A dry-dust or monolithic finish can only be used on fresh wet concrete and is especially useful when a colored surface is desired. The application and finishing process is the same whether the uncolored or colored dry mix is used.

After the concrete substrate has been poured and struck off or screeded, and the free water and excess moisture have evaporated from the surface, the surface should be floated to remove any ridges or depressions. If floated by hand, a magnesium or aluminum float should be used. Preliminary floating, which brings up moisture, should be finished before dry material is spread. If color is used, ridges or depressions may cause variations in color intensity. Immediately following the floating operation, some of the dry-dust materials should be shaken evenly, by hand, over the surface. In a few minutes, this dry material will absorb moisture from the plastic concrete, and should then be thoroughly floated into the surface. Immediately following this floating, the balance of the dry-dust material should be distributed over the surface, which should also be thoroughly floated and made part of the surface, obtaining a uniform color. All tooled edges and joints should be run before and after the applications.

Following final floating, the surface should be troweled. After the first troweling, enough time should elapse—depending on temperature, humidity, and other factors—to allow the concrete to increase its set. When the surface will not be marked by the knee boards, the final troweling is done to produce a smooth, dense, hard-wearing surface. The surface texture may be roughened as previously described. All precautions for protecting the surface should be followed.

SECTION F RECOMMENDED MAINTENANCE TO CORRECT DEFICIENCIES

When working with concrete, seasonal precautions must be taken to obtain the best results. In the winter, precautions against cold-weather damage should be taken, as well as those for hot-weather conditions.

Patching existing Portland-cement concrete pavement with cementitious mixes is preferable to bituminous

patching because it presents a uniform appearance of the pavement surface. However, bituminous patches may be necessary as a temporary measure, to be replaced later with a permanent cement-concrete patch.

Traffic should not be permitted on a fresh concrete or mortar surface until a sufficient strength has been reached to support the load. The concrete mix used and the temperature during the curing period will determine when the pavement may be opened to traffic.

The following concrete pavement failures (see Figure 4-2) are suitable for repair by maintenance personnel.

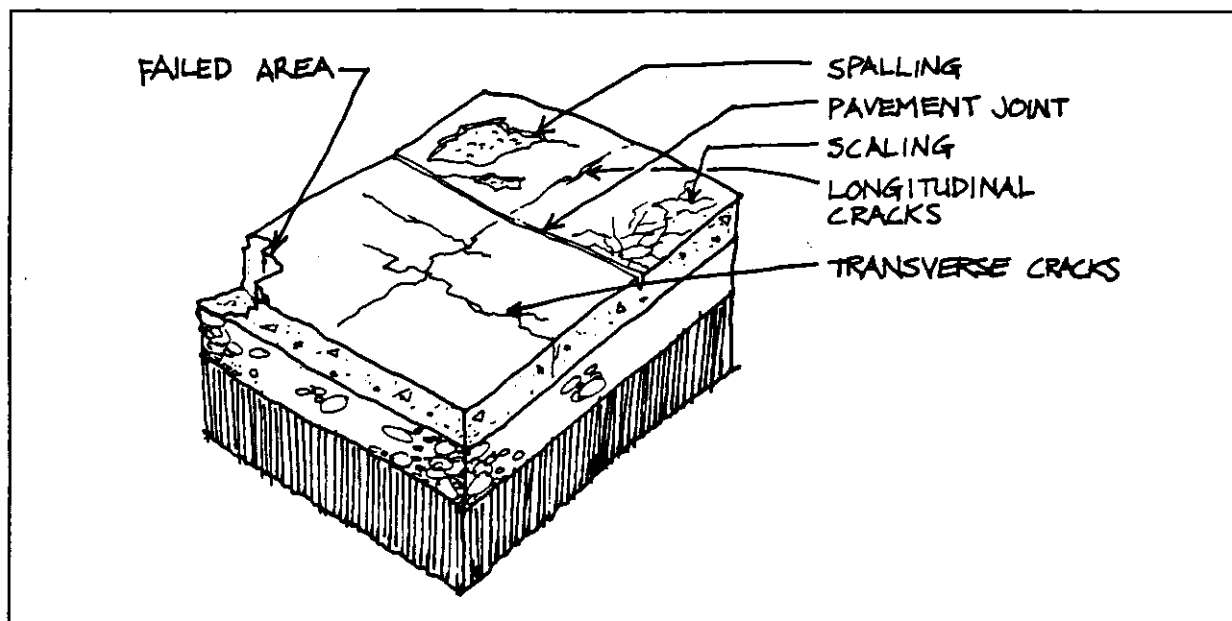


Figure 4-2: Types of Concrete Pavement Failures

1. LONGITUDINAL AND TRANSVERSE EXPANSION-JOINT FAILURE

a. Description of Deficiency

All concrete pavements expand or lengthen as temperatures increase, and contract or shrink when temperatures decrease. Concrete also expands when it absorbs moisture and shrinks with the loss of moisture. Longitudinal and transverse joints are constructed to permit such movement without damage to the slab. From a preventive-maintenance point of view, both require similar treatment to prevent water from entering the joints and causing deterioration.

When joints are not placed, or are improperly placed, random cracking occurs. These cracks should be filled with the proper type of joint filler or crack sealer to prevent water from entering the subbase. The best results are obtained by filling the defective joints or cracks when the pavement contraction is at or near its maximum size, consistent with working temperatures for the

sealer. Pouring of joint material should be done when necessary throughout the year; however, the pavement and joint should be dry, and the temperature above freezing. Joint filler that is poured when pavement is wet and the temperature is near or below freezing will not give satisfactory results. The pavement should be carefully checked late in the fall and again in the spring after snow removal and ice-treatment operations in order to ensure that all joints and cracks are properly sealed.

b. Materials, Equipment, and Personnel Required

See Chapter Three - Bituminous Pavement.

c. Recommended Repair Procedure

The following is the recommended repair procedure:

- Set up traffic signs; assign flaggers.
- Clean out old sealer, stones, and anything else which would prevent the slab from closing. Minimum depth for cleanout is 1-1/2 inches.
- Blow out joint; make sure joint is clean and dry.
- Repeat process where necessary.
- Fill joint to slightly under the pavement surface.
- Use joint dams made from cardboard if the sealer is running out of the edge of the slab. Several may be needed if the slab is on a sloped surface (see Figure 3-3).

2. SPALLING

a. Description of Deficiency

Spalling is the breaking, chipping, or fragmentation of a concrete slab, usually near joints, which is caused by defective joint construction or the infiltration of foreign and incompressible materials into the joint. Improper construction procedures include tipped or angled joints, bridging of concrete over expansion joints, incorrect installation of premolded strips or plates, the placement of inferior concrete, or excess finishing of concrete.

b. Materials, Equipment, and Personnel Required

- **Materials Required:**
 - Curing materials for all depths:
Depth = less than 1"
 - Bonding agent;
 - Mortar topping, sand mix;
 - Concrete or mortar sand as required;
 - Bonding agent;
 - Topping mix with 3/8" aggregate;
 - Concrete sand, small aggregate.
- **Equipment Required:**
 - Concrete mixer or mixing box as needed;
 - Screed (1"x 6" straight board, length at least two feet wider than largest patch for small patches);
 - Floats, trowels, edger;
 - Hand shovels, street brooms;
 - Forms where required;
 - Traffic signs and cones.
- **Personnel required, depending on the extent of the work:**
 - Supervisor, if necessary;
 - Concrete finisher;
 - Laborers.

c. Recommended Repair Procedure

- For all depths, set up traffic signs, assign flaggers.
- For depths of less than 1" to 3", note that the temperature of the underlying slab should be as near to that of the new concrete as possible. Warm concrete placed on a very cold slab will not bond well, and when the overlay has cooled, it may shrink enough to break away from the slab.
- Broom the area to be repaired.

- Check soundness of area to be repaired and the surrounding area (tap with hammer or drag a chain across).
- Remove any unsound pavement.
- Set forms to grade if required.
- Thoroughly sweep the area to be patched to remove any loose fine aggregate.
- Apply bonding agent or etch with acid and apply cement wash.
- Mix and apply topping mix.
- Finish patch to match surrounding pavement.
- Apply curing compound or wet burlap.
- Cure according to the topping mix used.

Concrete pavement with failures greater than three inches in depth should be replaced.

3. SCALING

a. Description of Deficiency

Scaling occurs when the surface of a hardened concrete slab breaks away or disintegrates from the paving surface, usually early in the life of slab. It can be caused by any of the following:

- Cycles of freezing and thawing, especially when nonair-entrained concrete was used.
- Applications of deicing salts when nonair-entrained concrete was used.
- Overworking the concrete during the finishing operations while bleed water is on the surface. Mixing this excess water into the top of the slab will cause a segregation of the surface fines (sand and cement) brought to the surface, and another layer of clean washed sand which is not bonded to the concrete under it.

b. Materials and Equipment Required

The same materials and equipment are required as for spalls of less than 1".

c. Recommended Repair Procedure

The same materials and equipment are required as for spalls of less than 1".

4. CRAZING AND MAP CRACKING

a. Description of Deficiency

Crazing or map cracking is the occurrence of numerous fine hairline cracks in the surface of a newly hardened slab due to surface shrinkage. These cracks are caused by any of the following:

- Rapid surface drying caused by high air temperatures, hot sun, drying winds, or a combination of these.
- Premature floating and troweling (floating and troweling when there is an excess amount of moisture on the surface or while the concrete is too plastic). Premature floating and troweling brings an excess amount of fines and moisture to the surface, resulting in crazing.
- Overuse of tamper, vibrating screed, darby, or bull float.

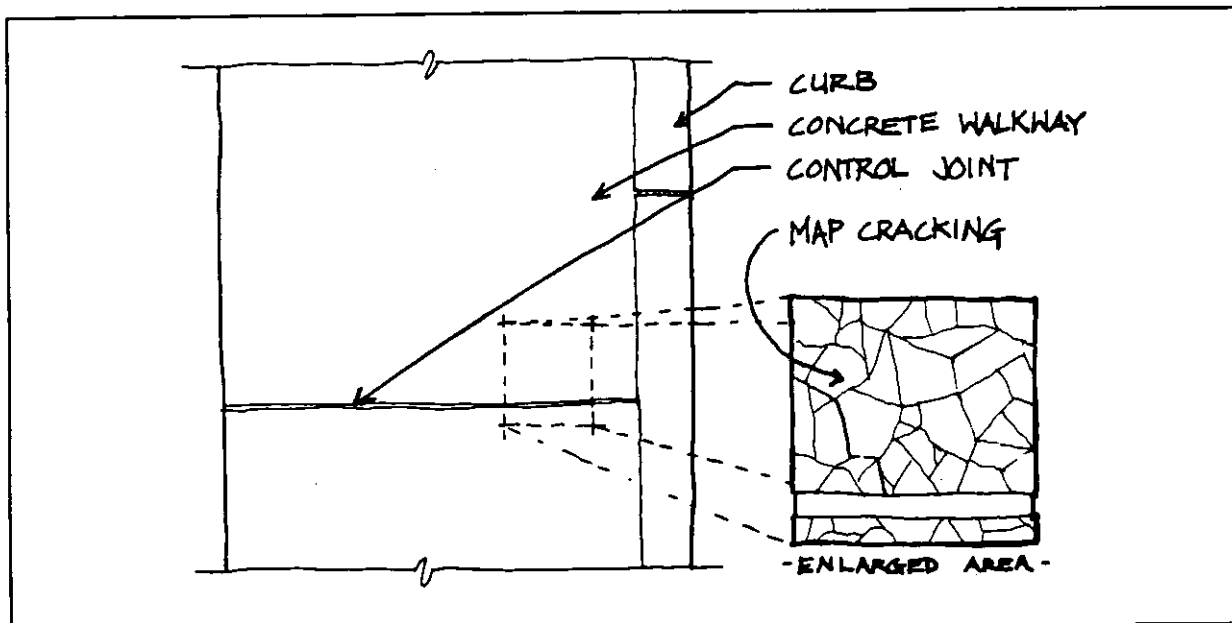


Figure 4-3: Crazing and Map Cracking

b. Recommended Repair Procedure

This is a minor defect and not worth the time and effort to repair. The cracks are extremely small and can't be sealed. The recommendation is to inspect these areas possibly twice a year, and if the cracks develop into spalls they should be repaired as necessary.

5. FAILED OR DISINTEGRATED AREAS

a. Description of Deficiency

This section deals with defects resulting from pavement or subgrade failures. Similar to bituminous pavement defects, the failures include potholes, edge failures, and other disintegrated areas requiring full or partial-depth patching. Failed pavement which has been badly cracked, broken, or disintegrated should be entirely restored to its original condition with new concrete.

b. Materials, Equipment, and Personnel Required

- **Materials Required:**
 - Ready-mixed concrete, preferably high early-strength. If ready-mix is not available, cement (preferably high early-strength, sand, stone or well-graded gravel aggregate, 3/4" maximum size) large patches.
 - Prepackaged concrete mix for smaller patches.
 - Water for mixing and cleaning up tools.
 - Curing compound or burlap.
 - Sand or base material, if needed.
- **Equipment Required:**
 - Dump trucks for hauling away removed concrete, sand, and aggregate if needed;
 - Truck to haul tools, forms, and prepackaged mix to job site;
 - Air compressor, jackhammer, air hose, tamper;
 - Rubber-tired loader to load broken concrete (for a large patch);
 - Concrete mixer; mortar box if hand mixing is necessary;
 - Forms, screed, finishing tools (floats, trowels, edgers, soft broom for texturing, large bucket to wash tools);
 - Shovels, picks, street brooms;
 - Signs, cones, lights, barricades for traffic management.
- **Personnel Required:**
 - Supervisor, if necessary;
 - Truck drivers, as needed;
 - Concrete finisher;
 - Laborers, as needed.

c. Recommended Repair Procedure

Depending on the size of the work, it is a good practice to have straight-line cuts either perpendicular or parallel to the center line. The thickness of a patch, in full-depth patching, should not be less than the existing slab. However, if the stability of the subgrade is questionable, but insufficient to warrant replacement, a greater thickness of concrete may be advisable.

Matching reinforcing steel should be replaced at the same spacing as that found in the existing concrete pavement. Expansion, contraction, or construction joints disintegrated through use or damaged during removal of broken concrete should be replaced, as nearly as possible in the same location and to the proper level. The defective area should be inspected and marked off, and all unstable materials removed and replaced.

- Set up signs; assign flagmen.
- Remove area to be patched.
- Trim excavated area as required.
- Refill with base material, stone screenings, or sand as needed, and compact.
- Set reinforcing steel as required;
- Wet down bottom of the excavated hole, but do not allow the water to puddle.
- If possible, coat sides of existing concrete with bonding agent and allow to become tacky.
- Pour concrete and finish.
- Apply curing compound or wet burlap.
- Clean up area and finishing tools.
- Do not open to traffic until the required curing time is over.
- Check often to make sure the burlap is kept wet if it was used. No action is necessary if curing compound was used.
- At the end of the curing period, remove burlap, remove forms if used, backfill where needed.
- Remove barricades and signs.
- Open to traffic.

END OF CHAPTER FOUR

MAINTENANCE GUIDEBOOK III - PAVEMENT MAINTENANCE

CHAPTER FIVE - APPURTENANT FACILITIES

SECTION A DEFINITION

Appurtenant pavement facilities are items such as manholes, inlets, and other drainage features located adjacent to or in the pavement. Other features such as walks, gutters, and drainage ditches are covered elsewhere in the Guidebook.

1. DESCRIPTION OF DEFICIENCY

The deficiencies include, but are not limited to:

- Cracked or broken inlet grates and frames;
- Broken manhole covers and frames;
- Clogged inlets and storm drains.

These facilities are generally considered trouble-free; however, regular maintenance inspections should be conducted in order to identify defects such as broken manhole frames or covers, or nonfunctioning storm inlets. These maintenance inspections should occur more frequently than those previously discussed, and should be conducted up close, not as a drive-by, since it is difficult to detect a clogged inlet or a cracked grate from a distance. Some manholes and sidewalks are owned by utilities or others. If any of these are found to be defective, notify the owners, who should do the repairs.

2. MATERIALS, EQUIPMENT, AND PERSONNEL REQUIRED

a. Materials Required

- Cleaning inlets and storm drains—None;
- Replacing grate, covers, and frames—Grate, frame, or cover as required. Note: This rarely needs to be done.
- Asphalt or concrete patching materials for repairing areas adjacent to inlet grates or manhole covers.

b. Equipment Required

- Truck, traffic signs, cones;
- Air compressor, air hose, jackhammer;

- Hand shovels, pick, street broom;
- Wheelbarrow or mixing box as needed;
- Hand tamp as needed;
- Heavy hammer or sledge, chisel;
- Heavy string (10 feet of grade line).

c. Personnel Required

Personnel required are a truck driver and laborers.

3. RECOMMENDED REPAIR PROCEDURE

a. Cleaning Inlets

- Set up signs.
- Remove trash from grates.
- Remove grates.
- Remove trash and debris from inlet.
- Check storm drain from both ends to be sure it is open.

b. Replacing Frames

- Set up signs.
- Cut around frame. The frame will have a flange which rests on the inlet or manhole. Be sure to cut back far enough to free the flange (about 8 to 10 inches).
- Remove grate or manhole cover.
- Remove frame.
- Remove mortar from top of inlet or manhole.
- Clean off top of inlet.
- Put down a bed of fairly stiff mortar on top of inlet.
- Set new frame to grade by placing string on the pavement surface on both sides of the frame (street side) as close to the frame as possible.
- Set frame. If too high, tap the frame with a pick or sledge. If too low, remove frame and add mortar. Repeat procedure on curb side. Perform both procedures together.
- Allow time for mortar to take an initial set.
- Replace carefully the removed pavement. Careless placement could cause the grate to move. If concrete is used, spray with curing compound.
- Set cones around inlet to protect from traffic.

- If asphalt mix is used, thoroughly tamp into place.
- Clean up area.
- Take down signs.

END OF CHAPTER FIVE

MAINTENANCE GUIDEBOOK III - PAVEMENT MAINTENANCE

GLOSSARY

ACID-ETCHING AND CEMENT WASH—Method of bonding fresh cement-sand mortar or concrete to existing concrete.

AIR-ENTRAINED PORTLAND CEMENT—A true Portland cement in which certain air-entraining materials are incorporated to produce a concrete resistant to severe frost and adverse effects of salt.

ALLIGATOR CRACKS—Polygon-shaped cracks connected together which are caused by repeated loads on a weak base and/or subbase, or movement of subbase.

BASE—A layer of gravel, crushed rock or stone, concrete or bituminous mixtures over the subbase.

BLEEDING—A black film on the surface on pavement caused by excessive liquid asphalt in the mix or poor gradation of the mix.

BLOCK CRACKS—Rectangular-shaped cracks caused by asphalt shrinkage or hardening.

BULL FLOAT—A large concrete finishing tool which has a rigid frame and handle.

BUMPS—Upward displacement of pavement caused by frost heaves, traffic loads, and concrete slab buckling under a bituminous pavement roadway.

CEMENT SAND MIX FINISH—Combination of Portland cement and graded sand.

CEMENT-SAND MORTAR TOPPING—A stiff, workable mortar just wet enough so all grains of sand are coated with cement paste, without excess water.

CONCRETE—A mixture of any type of Portland Cement, sand, gravel or stone and water.

CRAZING (MAP CRACKING)—The occurrence of numerous fine hairline cracks in the surface of a newly hardened slab due to shrinkage, caused by rapid surface drying, premature floating and troweling and/or overuse of tamper, vibrating screed, darby, or bull float.

CURE—To allow the pavement material to set up and harden.

DARBY—A straight-edged three-to-eight foot hand-tool used to level freshly placed concrete, before supplemental floating and finishing.

DRY MIX—Prepackaged concrete in which cement and gravel are proportioned and premixed at the factory.

EDGE FAILURE—Type of failure which appears along the edges of pavement not protected by a curb, walk or edging strips caused by poor construction, insufficient thickness, excessive loads and lack of shoulder support due to poor foundation.

EDGE CRACKS—Cracks close to the outer edge of the pavement caused by a weak base or subbase or a thin pavement section.

EPOXY-RESIN BONDING AGENTS—Adhesives used to bond fresh concrete or mortar mixes to existing concrete structures which will cure after being covered with wet concrete or cement mix.

EROSION—Deterioration, wearing away, disintegration by action of weathering processes such as wind and rain.

FEATHER IN—To gradually taper a material from a uniform depth to match an existing surface.

FOG—To lightly mist using a spray applicator in order to lightly wet the pavement materials.

FOUNDATION—The subbase and the base together.

HAIRLINE CRACKS—Narrow cracks caused by asphalt shrinkage, hardening, or lack of compaction during construction.

HIGH EARLY-STRENGTH PORTLAND CEMENT—Portland cement mixed with additional accelerating agents.

INORGANIC CONCRETE STAIN—A chemical solution which penetrates into the pores and forms its color through a reaction with the cement particles.

JOINT REFLECTION—Cracks in an overlay at the joints of concrete pavement.

LANE DROPOFF—Difference in elevation of adjacent lane caused by settlement or erosion of shoulder material.

LATEX CONCRETE PATCH MATERIALS—A general-purpose product, formulated primarily for use in area patching of concrete walks, floors, or other slabs and for levelling, consisting of latex (liquid binder) and powder (dry, premixed cement and fine aggregates).

LONGITUDINAL CRACKS—Cracks parallel to the length of the pavement caused by joint reflection, movement of base/subbase, or shrinkage/swelling of subbase.

MAINTENANCE—The work of keeping pavement in a state of good repair.

MORTAR—A mixture of cement or lime with sand and water used to bind two materials together.

PITTING—Small depressions where individual particles of embedded aggregate have popped out, caused by wear-and-tear and inherent faults of the pavement mixture.

PLANT MIX—Concrete purchased ready-mixed and ready to be placed.

PONDING—A saturated subbase or foundation caused by lack of proper drainage revealed by standing water and caused by buildup of soil on shoulders and adjacent grassed areas.

PORTLAND CEMENT—A general purpose cement suitable for all uses except when other types of concrete are required.

POTHOLE—Type of pavement failure which begins with a shallow surface failure which rapidly wears away, exposing the base and subbase, permitting water to gather and traffic to break down the bond. This develops into holes which resemble a pot. Causes of potholes include poor drainage and structural weakness.

PREPACKAGED DRY CEMENT SAND MIX—Prepackaged dry cement mix is one part Portland cement to two parts sand mix.

PREVENTIVE MAINTENANCE—Scheduling regular inspections and performing maintenance to prevent the development of major deficiencies or failures and to extend the life of pavement.

PRIME COAT—The application of a free-flowing liquid bituminous material to the surface to make repairs.

PRIMING—Waterproofing the surface by plugging capillary voids, coating and bonding loose mineral particles, hardening or toughening the surface and promoting adhesion with the superimposed surface course.

RAVELING—Wearing away of the pavement caused by loss of liquid asphalt and fine aggregate in the pavement.

RUTTING—A depression in the wheel paths caused by poor compaction in the subgrade or pavement or a weak mix.

SAGS—Displacement of pavement caused by frost heaves, traffic loads and/or concrete slab buckling under a bituminous pavement roadway.

SCALING—Deficiency which occurs when the surface of a hardened concrete slab breaks away, deteriorates, or disintegrates, usually early in the life of the slab. It can be caused by cycles of freezing and thawing, applications of salts and/or overworking the concrete during the finishing.

SCREED—Using a straight-edged tool to level materials and create a uniform surface.

SET—Used in conjunction with concrete work, set refers to the initial stiffening of concrete, and its final state of rigidity.

SETTLEMENT—Movement downward, sinking.

SHOULDER DROPOFF—Difference in elevation of adjacent lane caused by settlement or erosion of shoulder material.

SHOVING—Permanent longitudinal displacement of the pavement caused by heavy loads and/or heavy vehicles braking or turning.

SLIPPAGE CRACKS—Half-moon cracks pointing away from the direction of traffic caused by loss of bond between pavement lifts and heavy braking or turning vehicles.

SLURRY—A thin, water mixture of a fine insoluble material such as clay, cement, or soil.

SPALLING—The breaking, chipping, or fragmentation of the surface of a concrete slab, usually near joints, caused by defective joint construction or by damage due to infiltration of undesirable and incompressible materials into a joint.

SUBBASE—Undisturbed or compacted local soils graded and shaped.

SURFACE—Wearing course consisting of bituminous concrete, Portland-cement concrete, Portland-cement topping, fine cementitious materials, or a smooth compacted finish given to the low-type pavements such as gravel, crushed rock, or earth.

SWELL—Upward rise in pavement caused by some swelling clayey soil or frost.

TACK—For asphalt, a prime coat applied uniformly to enhance the bond between new and existing bituminous materials.

TAMP—To pack firmly or pound down by a series of blows or taps.

TRANSVERSE CRACKS—Cracks perpendicular to the length of the pavement caused by joint reflection, movement of base/subbase, or shrinkage/swelling of subbase.

WEATHERING—Wearing away of the pavement caused by loss of liquid asphalt and fine aggregate in the pavement.

END OF GLOSSARY